Playing With Dolls: Use of Simulation Technology in the Thompson Rivers University Respiratory Therapy Program

By

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We accept the thesis as conforming to the required standard

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Abstract

This descriptive case study examines the use of medical simulation technology in the three-year Thompson Rivers University respiratory therapy training program. Qualitative analysis of data gathered from 78 participants through interviews, observations, and discussion groups reveal a wide variety of low-intermediate- and high-fidelity technologies used for education and evaluation. Deliberate practice is the predominant learning theory informing the use of simulation for safe and ethical training in competencies that would otherwise pose significant risk to patients. Recommendations include enhancements of the existing technology with psychological and environmental fidelity, and for optimal curriculum placement of high-fidelity simulators at hospital sites for student development of critical thinking and team training. Further research into learning with high-fidelity simulation specifically within the context of a student respiratory therapist as an embedded hospital team member is needed.

Keywords: respiratory therapy, patient simulation, critical thinking, learning, critical care, deliberate practice
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Respiratory therapists (RTs) are allied health professionals and an essential member of the health care team. They possess a specialized body of cardio-pulmonary knowledge, with the majority of their skill base applied to the maintenance and care of airway and breathing. Many of the procedures performed by RTs have the potential to cause significant harm to a patient if not carried out correctly. In British Columbia (BC), the majority of therapists work in acute care facilities, caring for some of the most critically ill patients in the province.

There are 19 accredited training programs for RTs in Canada, with only one located in British Columbia; Thompson Rivers University (TRU) in Kamloops. The TRU program outputs 50-80 therapists annually from a three-year diploma or optional four-year baccalaureate program. A director oversees the program. Didactic faculty teach classroom and laboratory semesters on campus for the first two years, after which the students begin a ten month clinical rotation through a pediatric facility (BC Children’s Hospital) and a choice of two adult facilities in BC. During clinical rotations, the third-year students are partnered with RT staff preceptors at the bedside, and TRU clinical faculty who are contracted to work within each hospital site guide students through learning objectives.

Respiratory therapy is one of the only health care professions in Canada allowing entry-level (immediately after graduation) practice in critical care units. More than 80% of the basic RT competencies (procedures and skills) are at high-risk for causing significant harm to patients, and labeled as Restricted Activities under the BC Health Professions Act (Ministry of Health Services, 2010). Examples of these include invasive procedures (drawing blood from an artery or inserting a breathing tube into the trachea), therapies involving an artificial orifice (inserting a

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1 Nurses and physicians require additional training to work in critical care
tracheostomy tube into a hole in the neck), aerosolizing medication into the lungs, and use of mechanical ventilators to deliver oxygen or specialty gases.

BC is the only province in Canada where this health discipline is unregulated, with no professional college to protect the public and govern practice. There are approximately 1,000 therapists practicing in health authorities and private settings in the Province, without adequate means to ensure licensure and certification (Vergilio & Goodfellow, 2009). In the absence of a regulatory college, liability for unsafe practice is attributed to the employer; in most cases, this is a public hospital facility. Due to the high-risk nature of their work and lack of regulation in the clinical environment, it is imperative that training programs offer a way to acquire competency in skills and procedures before performing them on patients.

Simulation-based learning is proposed as an ethical and safe way to enable health professionals to acquire knowledge, skills and competencies while protecting patients from unnecessary harm (Ziv, Wolpe, Small, & Glick, 2003). Use of simulation technology is expanding rapidly in health care, as a means to provide education and evaluation for high-risk procedures in low-risk settings. The Canadian Patient Safety Institute issued a report on data gathered from 17 medical simulation centres, where 71% of responders identified RTs as primary users of simulation (2005). Asked to comment on the future of simulation in health care, one participant’s statement was “simulation will be completely embedded into the fabric of education” (p. 21).

The Council on Accreditation for Respiratory Therapy Education (CoARTE) holds Canadian RT training programs to national accreditation standards. These standards delineate the minimum acceptable training required for entry-level competencies, and specify whether the

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2 Prince Edward Island is also unregulated, but employs less than 15 RTs (Canadian Institute for Health Information, 2009)
RT must show proficiency in a clinical environment on a patient, using a simulator, or in a didactic setting for each.

As simulation technology becomes further integrated into RT training and professional development programs, it is imperative that the implementation is based on sound pedagogical theory and evidence so that graduates are fully prepared to deliver safe patient care. An assessment of the current technologies, including their application and rationale for use, will describe how one Canadian training program uses simulation within an accredited learning environment. Recommended best practices for use of simulation in health care training will provide a reference frame in which this case can be examined.

This research is designed to answer the question, “How does the Thompson Rivers University respiratory therapy training program use simulation technologies?” My goal is to provide an accurate picture of the history of simulation in the program, establish the technology in use, determine the application, and discuss the rationale for selection of technology fidelity. Exploring this research question within a conceptual framework of a descriptive study will provide me with an inquiry map and link my purpose to methodology and analytic techniques (Shields & Tajalli, 2006). Through the focused analysis of an intrinsic case study (Creswell, 2007), I will seek to provide an in-depth understanding of the use of this learning method bounded by the context of a training program for RTs performing high-risk activities in acute care facilities.
Literature Review

History

Developing in part from aviation’s rich history in simulation training, the use of simulated patients for health professionals became popular in the 1960’s with the first torso ‘Resusci-Anne’ doll for mouth-to-mouth resuscitation training, developed by Åsmund Laerdal (K. R. Rosen, 2008). Later, full-bodied mannequins evolved to become the computer-driven models available on the market today (Cooper & Taqueti, 2008; Grenvik & Schaefer, 2004). Further integration of physiologic realism occurs each year as the dolls become more technologically advanced (Good, 2003). The desire for human resuscitation has been one of the most influential movements behind the early adoption of simulation technology (Bradley, 2006), with its origins of chest compressions described in Hebrew Scriptures and mouth-to-mouth resuscitation reports from the early 15th century (Harris, 1992). Inflation of the lungs using manual bags and ventilators followed, and as this is the cornerstone of RT practice, it is no surprise that this profession has had over 30 years of history in the use of various types of simulation technology for education (Matthews & Yachemetz, 2008).

Typology and Classification

Simulators are designed to imitate the physicality or physiology of a human. They are roughly classified on a spectrum of low-fidelity to high-fidelity to indicate the “extent to which the appearance and behaviour of the simulator/simulation match the appearance and behaviour of the simulated system” (Maran & Glavin, 2003, p. 23). Low-fidelity simulators may be a simple plastic body part or mannequin. Intermediate-fidelity simulators may involve some computerized systems that display vital signs on a monitor or create a pulse under the skin, but usually require an instructor to create a physiologic change in response to a student’s care. High-
fidelity simulators are sophisticated full-body mannequins. They can be extraordinarily lifelike and have "computer programs driven by scientifically derived complex mathematical models of respiratory and cardiovascular physiology and extensive pharmacological modeling of drugs to produce a dynamic system" (Maran & Glavin, 2003, p. 25). These expensive dolls can even have a voice box (controlled by an instructor outside the room) so they may 'converse' with the trainee, vital signs, respirations, urine output, simulated blood and pulses, and eyes that move and exhibit pupillary reactions. Comprehensive circuitry allows pre-programming of vital signs to respond appropriately to therapies administered or intravenous medications (Maran & Glavin, 2003; Perkins, 2007).

Specific to RT training, high-fidelity full-body simulators often have an anatomically correct tracheo-bronchial tree, programmable breath sounds, the ability to mimic a swollen tongue or airway, can allow a needle thoracentesis, and have stoma openings to insert a tracheostomy tube. Some even have the ability to simulate the most difficult airway scenario, and clinicians can practice cricothyroidotomies and transtracheal ventilation (Schaefer, 2004). Lung simulators can be incorporated into full-body mannequins or designed as part-task trainers, and are a necessary part of training with mechanical ventilators. Earliest models were passive bellows-and-springs versions, but as the mechanical ventilators evolved in technological complexity, so too did the lung simulators. Current models can accurately simulate lung compliance and resistance, mimic spontaneous respirations, and allow gas readings for oxygen and carbon dioxide (Hinesly, 2005).

A simulated experience can be designed around the simulator to recreate other aspects of a scenario, and distinctions can be made between equipment fidelity (simulator realism), environment fidelity (sensory realism) and psychological fidelity (the degree to which the
participant can believe and become immersed in the scenario) (Beaubien & Baker, 2004; Maran & Glavin, 2003). A simulator with higher fidelity may not equate to advantages in learning, as one study showed: De Giovanni, Roberts, and Norman (2009) found that students training with high-fidelity simulators to diagnose heart sounds were no better at transferring these skills to practice than those training with low-fidelity simulators.

Further typologies of equipment fidelity have been reported in the literature. Maran and Glavin (2003) describe *part task trainers*, usually designed to replicate part of the human body or recreate a specific physiological function. *Computer based* simulations mimic physiology, environments or tasks through a computer interface (Alinier, 2007; Maran & Glavin, 2003; Perkins, 2007), and this format was adopted for use in the RT credentialing examination in the United States (Cullen & Koss, 1999; De Kler, 1997). Computer simulations may be the most cost-effective way to recreate complex scenarios, and were used effectively in training medical students to manage a large-scale disaster in emergency medicine (Franc-Law, Ingrassia, Ragazzoni, & Della Corte, 2010). The clear advantage of computer simulations is that they can be shared between sites or even internationally (Huang, Reynolds, & Candler, 2007). *Virtual reality* or *haptic* systems recreate a scenario with users fully immersed with multiple senses, such as simulating touch and sight for invasive medical procedures (Gallagher et al., 2005; MacIntyre, 2004; Maran & Glavin, 2003; Schaefer, 2004).

Environmental and psychological fidelity can also be realized using *simulated patients*. These are typically actors who participate in training scenarios, often for the purpose of teaching interpersonal skills (Maran & Glavin, 2003). They have been used for years in teaching aspects of physical assessment (Barrows, 1968). One group of authors compared simulated patients and real patient interactions and found that although medical students learned more from real patient
encounters, the students reported the simulated patients helped to build their self-confidence (Bokken et al., 2009), and provided excellent feedback during training (Bokken et al., 2010). Several studies recommend combining simulated patients with clinical simulator equipment to gain positive aspects of both experiences (Kneebone, Nestel, Vincent, & Darzi, 2007; Kneebone et al., 2006; Laack, Newman, Goyal, & Torsher, 2010; Nestel & Kneebone, 2010). Simulated patients are also used as an accepted means to evaluate performance in clinical assessments (K. R. Rosen, 2008; Scalese, Obeso, & Issenberg, 2007; Ziv, Small, & Wolpe, 2000), and a growing number of healthcare quality improvement groups are recommending simulation training to promote patient safety.

**Patient Safety**

Patient safety is an important issue in health care, with much room for improvement. In the year 2000, a retrospective Canadian patient chart review of adverse events (defined as unintended injuries or medical complications) in a sampling of hospitals across five provinces showed an incidence of 7.5%, with 2.8% of them thought to be preventable (G. R. Baker et al., 2004). An analysis of a safety reporting system from 23 American critical care units revealed 2075 safety incidents over two years, with 42% of these resulting in patient harm, including 18 deaths. Lack of adequate training and education was the highest contributing factor, leading to 49% of the reported incidents (Pronovost et al., 2006).

Recognizing that simulation has the potential to improve patient safety, the Canadian Patient Safety Institute developed a national structure in 2007 to promote and coordinate simulation efforts to improve the training of health professionals. This has promoted an increased interest in the use of simulation technology to improve the safety of Canada’s public health care system, and has “challenged the traditional ‘learning by doing’ approach to
healthcare education” (Canadian Patient Safety Institute, 2005). Simulation technology can additionally be used to teach leadership skills, communication, coordination, cooperation, and error resilience, all of which are system hallmarks of a high-reliability system (Shapiro et al., 2008). Interestingly, although simulation use for health care training often draws parallels to the field of aviation, the solution to approaching this industry’s excellent safety record may extend beyond training programs and require a climate of safety to permeate all aspects of the organization (Gaba, Singer, Sinaiko, Bowen, & Ciavarelli, 2003).

The culture of medical training has historically followed the adage, ‘See one, do one, teach one’. This model of apprenticeship may work well for other professions where the results of error or incompetency lead only to inadequate performance, but is no longer acceptable in health care where consequences can prove detrimental to health or life (Bandali, Parker, Mummery, & Preece, 2008; Scalese et al., 2007). Ziv, Wolpe, Small, and Glick (2003) describe some of the ethical benefits of using simulation technology for medical training. These include training professionals to the highest possible standards, providing the ability to learn from and gain insight into the management of medical errors, and protecting patients from being used for unethical training purposes. The traditional adage may need to change to: “See one, do one, teach one…just not on my Mom” (Brindley, Suen, & Drummond, 2007, p. 22).

Encouraging a culture of error in medical training empowers clinicians to experiment with their practice, to take risks, and to see consequences when errors are allowed to play out. Rather than preventing mistakes from occurring altogether, simulation permits them and allows important learning to take place in their mitigation (Ziv et al., 2000). A high level of complexity and stress in emergency medical situations means that human error will always occur, but an RT who has trained for every eventuality in a simulated environment may be able to react quickly
and appropriately to reverse the medical consequences of the mistake. This alone provides a convincing argument to promote assimilation of this technology into RT training programs.

**Applicability to Respiratory Therapy**

The nature of respiratory therapy as a profession performing high-risk activities lends itself well to learning in simulated environments. Just as with the field of aviation, inadequate training or errors can cost lives. A health profession highly reliant on advanced technological machines for delivery of patient care, RTs are well suited to guide simulation design (Frembgen, 2006) or to assist with the technological aspects of running a simulation training program as they do in Rochester, Minnesota’s famous Mayo Clinic (Diulio, 2008).

Respiratory therapy is a profession where theoretical knowledge of anatomy and physiology combines with procedural skill and equipment expertise to deliver care. Within training programs, physiologic rationale must be applied to patient care decision-making. One simulation program for medical residents explains how simulation training scenarios are related back to the underlying cardio-respiratory physiological principles (i.e. pulmonary shunt and deadspace, alveolar-capillary diffusion, blood gas interpretation) to reinforce learning objectives and build theoretical knowledge in conjunction with procedural skills (Euliano, 2000, 2001).

Simulation technology provides access to training for skills that may occur infrequently in the clinical environment (Brindley et al., 2007; Crofts et al., 2006; Kneebone et al., 2007; Ziv et al., 2006). The Canadian National Competency Profile (National Alliance of Respiratory Therapy Regulatory Bodies, 2003) for respiratory therapy, to which all training programs in Canada are accredited, includes high-risk procedures on neonatal and pediatric populations such as insertion of an artificial airway and CPR. Although all trainees spend time working with children and infants during their clinical rotations, there may be little exposure to emergency
scenarios required to meet certification standards. Simulation technology is able to provide this high-risk pediatric experience (Crofts et al., 2006; Eppich, Adler, & McGaghie, 2006). The most recent version of the National Competency Profile accepts competency in a simulated environment for certification in some skills that may not be encountered by the RT during clinical student placement (National Alliance of Respiratory Therapy Regulatory Bodies, 2011).

Simulation creates a peril-free environment to train for scenarios that may otherwise put the respiratory caregiver at risk. During the outbreak of Severe Acute Respiratory Syndrome in 2003, 11 healthcare workers became infected in Canada, and three died (Maunder, 2004). One Toronto hospital subsequently used simulation to test a new protocol for cardiac arrest in a mock patient with Severe Acute Respiratory Syndrome, allowing the team to gain skill and experience in putting on full-body protective suits to deliver patient care should they be faced with a real scenario (Abrahamson, Canzian, & Brunet, 2006).

Simulators have been used to teach advanced life support resuscitation for over 40 years (Bradley, 2006; Matthews & Yachemetz, 2008; Perkins, 2007). Both low-fidelity and high-fidelity mannequins are useful for teaching the aspects of resuscitation that RTs are typically responsible for during a ‘code blue’. Intubation, bag-mask manual ventilation techniques, oral and tracheal suctioning, mechanical ventilation, securing an artificial airway, manual airway opening techniques, chest compressions, abdominal thrusts, and airway foreign body removal are easily simulated (McIvor, 2004) to practice skills and help the clinician develop a resuscitation routine. Simulated resuscitation training has been shown to improve the quality of care by physicians during real code blue events (Wayne et al., 2006, 2008).

Bronchoscopes, equipment used to fiberoptically view a patient’s airway and lungs, can be modeled through simulation for RT training purposes. Computer generated simulations can
provide a very realistic re-creation of the tracheobronchial tree and pathologies. Movement through the airways can be controlled with a computer keyboard or by using a real bronchoscope inserted into a sensing device that tracks the position of the scope and matches it with the view on screen. Images can also be created through digitized 3D computed tomography (CT) scans (MacIntyre, 2004). Studies have shown that training with virtual reality bronchoscopy simulators can significantly increase speed, accuracy, and manual dexterity in physician trainees (Colt, Crawford, & Galbraith, 2001; Rowe & Cohen, 2002).

Mechanical ventilation is a significant part of the role of the RT in critical care units. As these life support machines become more technologically complex, RT education programs have a responsibility to keep pace with adequate means of training. Online web-based computer simulation programs can be used to recreate the ventilator screen, allowing clinicians to manipulate parameters and see virtual patient results (Wax, Kenny, & Burns, 2006). Alternatively, mechanical lung simulators can be attached to real ventilators and set to simulate changes in lung physiology. In her article ‘The current state of lung simulators’, Dana Hinesly describes how this technology is being designed for specialized purposes. One example is a simulator designed to mimic the sound of a person breathing when trapped under rubble after an earthquake (Hinesly, 2005) for search and rescue training. Lung simulators by themselves don’t seem to offer any advantage when learning mechanical ventilation over traditional lecture formats – although the study purporting this provided instruction with demonstrations only, and did not provide students with opportunities for interaction (Johnson, 2008).

There is general recognition that despite training as a single discipline, upon graduation, medical professionals are thrust into an environment where they need to function effectively as part of an interdisciplinary team. The use of simulation for team-based training in ongoing
professional development is widely reported as a successful technique to improve patient safety and quality of care (D. P. Baker, Gustafson, Beaubien, Salas, & Barach, 2005; Beaubien & Baker, 2004; Brindley, Suen, & Drummond, 2008; Davis, Riley, Miller, & Hansen, 2008; Gaba, Howard, Fish, Smith, & Sowb, 2001; Lighthall et al., 2003; Salas, DiazGranados, Weaver, & King, 2008; Shapiro et al., 2008; Wayne et al., 2008). RTs are frequently designated as part of an interdisciplinary resuscitation or rapid response team, and are often involved in simulation training for professional development in this context (Abrahamson et al., 2006; DeVita, Schaefer, Lutz, Dongilli, & Wang, 2004; Diiulio, 2008; Lighthall et al., 2003). Modeled after crew resource management techniques in the airline industry, anesthesiologists have developed crisis resource management techniques to address system failures in health care, using simulation to improve their operating room teams’ skills and behaviours (DeVita et al., 2004; Gaba et al., 2001; Gardner, Walzer, Simon, & Raemer, 2008). Crisis resource management models are now used to train other hospital teams (Gardner et al., 2008; Hammond, 2004; Kim, Neilipovitz, Cardinal, Chiu, & Clinch, 2006; Lighthall et al., 2003; Shapiro et al., 2008), including those with RTs.

Hill (2002), in a study that found a significant correlation between critical thinking and decision making in RT students, noted that RT program directors and faculty were of the opinion that simulation was an important strategy for the development of those skills. Experiments using simulation technology for training other health professions have similarly reported a statistically significant increase in confidence, decision-making ability, and clinical judgment in nurses (Bambini, Washburn, & Perkins, 2009; Cant & Cooper, 2010; Dillard et al., 2009; Parr & Sweeney, 2006) and physicians (Marshall et al., 2001; Takayesu et al., 2006). The National American certification exam for RTs utilizes computer simulations to assess critical thinking and
problem-solving abilities as part of its certification process (Cullen & Koss, 1999).

Other behavioural markers, required to function successfully as an RT in an interdisciplinary team environment, can be taught or evaluated using simulation technology. One interesting article describes how the Apollo 13 movie (where astronauts were faced with extremes of adversity and needed to utilize strengths in teamwork, ingenuity and determination to return safely to earth) can be used as a preview in simulation-based learning scenarios to demonstrate these principles to participants (Halamek, 2010). Communication skills can be enhanced through training with simulated patients or simulators, independently or as part of team training (Bandali et al., 2008; Kneebone et al., 2006; Laack et al., 2010; M. A. Rosen et al., 2008; Salas et al., 2008; Scalese et al., 2007; Shapiro et al., 2008; Takayesu et al., 2006; Ziv et al., 2006). This has been particularly helpful for hospitals spread across a large geographic area as in Canada, where telephone communications between sending and receiving hospitals have been simulated to improve patient coordination (Brindley et al., 2008).

Incorporating this exciting technology into medical training programs should be guided by a conceptual framework; something that is not often described in experimental studies within medical literature (Bordage, 2009). Relating the rationale to the theoretical underpinnings beneath can provide structure and support to the use of simulation technology in medical learning contexts.

**Theoretical Frameworks for Learning**

Learning through simulation technology can occur in many ways, and likewise is supported by many theoretical frameworks. Rather than focusing on a single theory, this literature review will explore several that are reported in the simulation literature. Using Bordage's (2009) analogy of conceptual frameworks as lighthouses and lenses, scanning all
relevant theories before focusing a lens on those most applicable will provide a structure for illumination and magnification in learning through simulation.

Operating without a conceptual framework or jumping quickly, consciously or not, onto a single framework without exploring others will leave you short-changed, given the range of possibilities available. Other frameworks might cast a different and richer light on the issues at hand (Bordage, 2009, p. 313).

For the acquisition of cognitive skills, the most widely recognized learning theory for simulation technology is *deliberate practice*. Kneebone, Scott, Darzi, and Horrocks (2004) provide a good summary of how expertise is developed; through sustained and purposeful practice, over a period of at least 10 years, and with specific goals, reflection and feedback. Ericsson (2004, 2008) expands on this by describing how individual performance can be measured by levels and over time, and reaffirms the key features that separate the development of *experience* from *expertise*: 1) goals, 2) motivation to improve, 3) feedback, and 4) repetition and refinement. Hence, the development of expertise in cognitive domains is described as *deliberate* practice.

Lev Vygotsky was a Russian psychologist (1896-1934) who postulated there was a *Zone of Proximal Development* (ZPD) for a learner, where expert support could be gradually withdrawn as the student progresses. Kneebone (2005) describes how the Vygotskian ZPD model was later modified to become a “dynamic, often recursive process where each learner first receives external help, then performs under conscious guidance from the self, and finally internalizes the process to render it automatic” (p. 550). The deliberate practice model, incorporating Vygotsky’s ZPD and Ericsson’s features of the acquisition of expertise, is ideal as an underpinning for learning through simulation technology.
Deliberate practice has been used successfully as a theoretical framework to test learning in a variety of simulation settings (Abrahamson et al., 2006; Adler et al., 2009; Marshall et al., 2001; Wayne et al., 2006, 2008) and is supported as an effective learning theory for health care simulation in many reviews (D. P. Baker et al., 2005; Cant & Cooper, 2010; Eppich et al., 2006; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Okuda et al., 2009; Perkins, 2007; Wang et al., 2008). A key systematic review of evidence between 1969 and 2003 looking at uses of simulation that led to effective learning (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005) found that 47% of articles identified the provision of feedback was the most important feature, and 39% of journal articles identified repetitive practice as key. In combination, these features describe the deliberate practice model. The same authors later did a quantitative analysis of a subset of this review, and found there was a positive dose-response relationship to the number of hours of practice on high-fidelity simulators and standardized learning outcomes (McGaghie, Issenberg, Petrusa, & Scalese, 2006).

The importance of feedback as a part of the deliberate practice model can be ascribed to behaviourist learning theory, when simple positive and negative guidance is given during repetitive practice. With simulation technology, the terminology used for the feedback mechanism is *debriefing*. Dreifuerst (2009) links debriefing with *reflective learning*, a process that is a crucial step in developing critical judgment. The act of reflective learning has been used successfully in simulation curriculums (Bond et al., 2004; Dillard et al., 2009; Fanning & Gaba, 2007; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005). When debriefing is used to facilitate reflection with team training, a constructivist learning theory applies as the students use the reflective process to promote assimilation and accommodation of new information into their personal cognitive schema (Bradley & Postlethwaite, 2003a; Perkins, 2007; Weller, Robinson,
Larsen, & Caldwell, 2004). The process of debriefing during and after simulation is also a part of the ‘reflection-on-action’ portion of Kolb’s experiential learning cycle (Brindley et al., 2007; Fanning & Gaba, 2007; Waldner & Olson, 2007).

The simulation literature provides guidance for correct debriefing. One study has shown that debriefing is most effective if it takes place after the simulation, not during (Van Heukelom, Begaz, & Treat, 2010). Susan Pasquale (2010, p. 87) provides a list of factors that may detract from the debriefing process:

1. Lack of an initial explanation of purpose or objectives.
2. Excessive instruction discussion.
3. Closed questions and excessive criticism or negativism of learner’s performance.
4. Consuming excessive time on medical issues.
5. Highlighting too many key teaching points.
6. Underestimation of trainee emotions.
7. Autocratic attitude of debriefer.
8. Allowing discussion to focus on the limitations of simulation.

She additionally lists key features characterizing a successful debriefing process:

1. Create a friendly and confidential learning environment.
2. Provide pre-simulation expectations.
3. Encourage questions supportive of self-critique while fostering discussion.
4. Reinforce principles, correcting a limited number of errors.
5. Avoid excess correction or criticism.
6. Stress a key number of educational points.
7. Use visual aids, including the use of video, to review concepts or actions.
8. Avoid creating an excessively long debriefing.

By following the recommendations and avoiding pitfalls, the author suggests debriefing can benefit both learner and instructor.

Lave and Wenger's (1991) concept of learning through legitimate peripheral participation within a community of practice can be applied to simulation training. The notion of gaining knowledge and information when students are relegated to the sidelines but embedded within the contextual ‘clinical’ learning environment suits a constructivist epistemology, and is most applicable to team training or group learning using simulation technology, where each learner builds and contributes relevant knowledge for others during simulated scenarios. Elfrink, Nininger, Rohig, and Lee (2009) describe the importance of group learning after noting the reluctance of nursing students to be ‘singled out’ during team training. In his activity theory, Engestrom (2001) proposes learning occurs in a unit of analysis and across the boundaries of the activities a learner involves himself in. In simulated environments, the challenge for his activity theory is how knowledge transfer occurs when moving outside of the primary activities and into a real-world environment (Bradley & Postlethwaite, 2003a).

Brydges, Carnahan, Rose, Rose, and Dubrowski (2010) studied medical students progressing through a sequence of simulators with increasing fidelity, and found performance increased when learners could self-monitor their performance. They concluded that self-guidance was an effective way to learn with simulation. Chang, Petros, Hess, Rotondi, and Babineau (2007), however, found that voluntary use of simulation technology in a surgical resident training program was not conducive to learning as their results showed participation was minimal.

The social role of group learning with simulation can be related to aspects of several
theoretical frameworks. With roots in Vygotsky’s *social development theory*, Bandura's (1977) *social theory* uses principles of behaviourism and cognitivism to describe how learning takes place through student motivation and the attention to, retention of, and reproduction of behaviour modeling. LeFlore and Anderson's (2009) experiment also supported behaviour modeling, determining this was more effective for team training than self-directed learning. Dieckmann, Gaba, and Rall (2007) take social theory further with descriptions of Uwe Laucken’s differentiation of three aspects of social realism (physical, semantical, phenomenal), Erving Goffman’s analysis of the relationship between real patient cases and simulated ones, and Hans Vaihinger’s *as-if* concept, describing the level of realism necessary for the learner to suspend disbelief during a simulated scenario. The concepts they describe are useful when designing simulation curriculums, to “transform the salient characteristics of clinical tasks into meaningful and relevant scenarios, to increase simulation fidelity where and how it is needed, and to depart from realism where appropriate” (Dieckmann et al., 2007, p. 191).

Parker and Myrick (2009) reviewed the pedagogy to support use of simulation in nurse education and recommend behaviourism as the best fit for rote learning of psychomotor skills using low-fidelity equipment such as part-task trainers. They go on to prescribe constructivism as best used with high-fidelity equipment to develop skills such as problem-solving, clinical judgment, collaboration and team training, and advise that educators use both learning theories while developing simulation-based curriculum. Binsteadt et al. (2007) used similar pedagogical consideration while redesigning a curriculum to incorporate simulation for emergency medicine residents. They used principles of cognitivism to scaffold learning, thereby building a base knowledge in procedures; then used higher fidelity simulation to teach decision-making, skill performance and finally teamwork. *Scaffolding theory* was also judged as effective in guiding
medical students through a series of progressive steps within simulation curricula (Brydges et al., 2010; McClusky & Smith, 2008).

One article describes a conceptual framework for simulation based on pharmacology. This odd analogy uses pharmacokinetics (rate of drug absorption, rate of learning absorption) and pharmacodynamics (effect of the drug on a patient, effect of the simulation training on real-life practice) as an epistemology for designing a simulation curriculum for medical training programs. Other pharmacology terms and relationships are used such as dose-time, dose-effect, and drug-drug interactions to describe simulation effects on learning (Weinger, 2010).

In addition to its usefulness in teaching as supported by these learning theories, simulation technology can be used to evaluate learning that has taken place either within training programs or in a clinical environment with working health care professionals.

**Use for Performance Evaluation**

Simulation technology has been shown to be a reliable and valid method to assess skills performance in an evaluative role (Hatala, Kassen, Nishikawa, Cole, & Issenberg, 2005; Murray et al., 2002; Rosenblatt, Abrams, & New York State Society of Anesthesiologists, Inc., 2002; Tsai, Harasym, Nijssen-Jordan, Jennett, & Powell, 2003; Weller et al., 2003). One study trained 24 medical students and assessed their knowledge with written examinations, objective structured clinical examinations (OSCE), and simulation technology exams. The written exams were effective only at assessing knowledge, and could not measure the student’s ability to apply learning to problem solving. The OSCE and high-fidelity simulator were equally effective at assessing skills; a similar result reported by other authors (Gordon, Tancredi, Binder, Wilkerson, & Shaffer, 2003). The simulator was particularly effective at assessing higher analytic skills (Rogers, Jacob, Rashwan, & Pinsky, 2001). Devitt, Kurrek, Cohen, and Cleave-Hogg (2001)
were able to demonstrate construct validity and medical students reported a high level of realism when using simulation for evaluating anesthesia practice.

Using simulation technology for performance evaluation, particularly when assessing high-risk procedures or high-stakes licensure examinations, requires attention to quality assurance (QA) to ensure consistency and standardization. Furman, Smee, and Wilson (2010) compared QA across three organizations and recommended:

- quality control is critical to provide valid and reliable simulation assessment;
- case development should be a collaborative process; and
- ensure training and standardized practice for raters and coordinators.

Simulation technology is evolving as a mechanism for competency assessment and performance evaluation for RTs. Tuttle et al. (2007) used a full-body patient simulator to train and evaluate staff RTs in the use of broncho-alveolar lavage (a lung wash technique) as a safety improvement on their traditional apprenticeship learning model, where the skill was acquired through repeated practice on real patients. Designed as a quality improvement study without a control group or randomization, their results were not conclusive but suggested that simulation accelerated learning and improved knowledge retention when compared to traditional methods. Other benefits to using simulation for evaluative purposes include reproducibility of patient scenarios (reliability) and confidence in testing applicable content (validity) (Scalese et al., 2007). Maran and Glavin (2003), however, caution that performance assessment on human patient simulators will never equal the reliability, validity, and accuracy of simulation used in the aviation industry due to “the unpredictability and complexity of the human patient, [and] the lack of physiological data from pathological states” (p. 27).
Curriculum Integration

Several studies describe the integration of simulation technology into a medical curriculum. Issenberg (2006) identifies three essential components, and indicates the absence of one will likely cause failure:

- Training resources. This encompasses the simulation equipment, physical space, and adjunctive equipment or technology used to create a simulation scenario.

- Trained educators. This is comprised of dedicated staff that has received specific instructions on using the equipment and running a scenario, as well as administrators or coordinators for running the program.

- Curricular institutionalization. This includes the integration of a simulation program into the organization’s budget and vision, including commitment to a culture of patient safety and the goal to improve skills and competencies in health care providers.

Issenberg (2006) additionally proposes five levels of innovation that describe a teaching program’s adoption of simulation technology into their curriculum: (a) awareness, (b) interest, (c) evaluation, (d) trial, and (e) adoption. He further emphasizes that in order for successful adoption to occur, a program needs to be led by a visionary risk-taker who is focused on technology, as well as members who will look for evidence and be proponents of change. Equally important is the need for instructors trained to teach with simulation technology. The author cautions, “educator competence in the expert use of simulation must be assured, not assumed” (Issenberg, 2006, p. 206). In a critical review of simulation literature spanning 2003-2009, McGaghie et al. agreed, emphasizing “effective SBME [simulation-based medical education] is not easy or intuitive; clinical experience alone is not a proxy for simulation instructor effectiveness, and simulation instructors and learners need not be from the same health
care profession” (McGaghie et al., 2010, p. 59).

Simulation technology may not be a replacement for proven effective teaching methodologies in the health sciences. For example, case-based or problem-based learning strategies provide students with a patient ‘case’ in a classroom, often with a history, vital signs, static images of ECGs and x-rays, and descriptions of signs and symptoms. Students generally discuss and work through the case to learn management strategies. When compared to high-fidelity simulation, Schwartz, Fernandez, Kouyoumjian, Jones, and Compton (2007) found that student performance was not improved when compared in a randomized controlled trial with traditional case-based learning. In another comparison trial, Wenk et al. (2008) reported that although medical students did not score differently in performance, they overrated their self-assessed abilities after simulation. Some studies have found that medical students prefer learning with or perform better with simulation than with problem-based learning (Murphy, Engle, Jorns, Herrington, & Lindsey, 2009; Steadman et al., 2006). Others have used simulation to augment case-based learning within a redefined curriculum (Wang & Vozenilek, 2005).

A comprehensive search spanning four decades synthesizes features and best practices in medical simulation technology for education (McGaghie et al., 2006). The authors summarize recommendations for (a) providing student feedback, (b) deliberate practice, (c) curriculum integration, (d) outcome measurement, (e) simulation fidelity, (f) skill acquisition and maintenance; (g) mastery learning, (h) transfer to practice, (i) team training, (j) high-stakes testing, (k) instructor training, and (l) educational and professional context. Published reports describing simulation within a Canadian RT program exist (Gallant, 2008), but do not provide a comprehensive overview of all aspects listed above.

Rather than integrating simulation technology individually within each medical training
program, some countries have successfully developed comprehensive multidisciplinary simulation centres. The Israel Center for Medical Simulation in Tel HaShomer, Israel, is one example of a simulation centre that provides training and performance testing for paramedics, nurses, physicians, pharmacists, social workers, physical therapists, occupational therapists, and health managers. The centre additionally incorporates research and development programs “aiming to validate SBME and development of new simulation modalities” (Ziv et al., 2006, p. 1094). To address the importance of trained simulation instructors, this centre provides a ‘train the trainer’ program. They gain financial support from and maintain collaborative partnerships with academic institutions, their Ministry of Health, the Israel Defense Forces Medical Corps, emergency medical services, hospitals, philanthropic foundations, medical supply and pharmaceutical industries, HMO’s, and professional associations. This model is a good example of how simulation has changed the culture and tradition of medical training within one country.

Diametric to building a national multidisciplinary simulation centre is providing portable technology to roam between external locations. Kobayashi et al. (2008) depicts benefits to portable equipment including enhancing the clinical environment by locating the training closer to the context, enhancing delivery of training to remote locations, and supporting interdisciplinary training with ease of access to on-site teams.

In 2001, Harvard Medical School set up an off-campus simulation centre. Their initial steps included appointing interdisciplinary leadership, securing capital equipment and training from a simulation technology company, designating space for lab and storage, and collaborating with local hospitals and university programs. After a period of trial and error, simulation was integrated into the curriculum of preclinical education (e.g. to teach motor skills and physiology), transitional education (e.g. for patient interview and examination skills), and clinical education
Running head: PLAYING WITH DOLLS

(e.g. to manage patient cases). This simulation centre boasts an on-call physician education team including faculty and residents, technician, clinical educator, and research position to support education sessions, supplied to students on-demand (Gordon, Oriol, & Cooper, 2004).

In a somewhat smaller curriculum integration, Issenberg, Pringle, Harden, Khogali, and Gordon (2003) outline how a human patient simulator was immersed into all phases of an undergraduate cardiology medical training program. Bradley and Postlethwaite (2003b) describe a similar program, but recommend the addition of senior academic leaders among the support staff, in order to promote research and ensure the learning of required competencies. In one American state, simulation has already been integrated into all community college medical training programs (McLaughlin, Starobin, & Laanan, 2010).

**Barriers and Disadvantages**

Ziv et al. (2000) describe barriers to the integration of simulation technology in educational institutions. Prolonged time or reluctance to incorporate a new method of learning into an established culture holds some programs back from change. Another impediment can be the lack of validated and reliable curricula. Several authors describe the importance of having dedicated and trained instructors for delivering quality education programs using simulation (Good, 2003; Issenberg, 2006; McGaghie et al., 2010; Okuda et al., 2009; Perkins, 2007; Ziv et al., 2000). Knowledge transfer methods from a simulated to a clinical environment are not clearly understood, and technology costs are considerable and may be prohibitive (Gaba, 2004; Good, 2003; Okuda et al., 2009; Perkins, 2007; Ziv et al., 2006).

Perkins (2007) describes a phenomenon that may occur in simulation training, where the learner becomes hyper-vigilant in preparing for the simulated event, something that may not be as likely to happen in a real clinical setting. In addition, “cavalier behaviour can occur as it is
clear that a human life is not at stake” (Perkins, 2007, p. 209). A less common, but problematic barrier to overcome, are students with pediophobia (fear of dolls, mannequins or other human representations). These students may find it difficult to participate in programs incorporating simulation (Smith-Stoner, 2009).

Is overcoming the barriers and challenges to simulation use a worthwhile endeavor? A scan of the literature in relation to learning and other outcomes identifies further positive aspects to the incorporation of this technology into medical training programs.

Outcomes

Retention of knowledge after simulation training has not been extensively studied. In a quality improvement project using simulation to train RTs, skills learned with simulation technology (mean = 95%) and retested after 90 days were almost fully retained (mean = 92%) (Tuttle et al., 2007). A study with anesthesiologists looked at duration of difficult airway skills retention after simulation training, and found most skills were retained up to six weeks, and some for up to six months. They concluded that retraining for emergency procedures should be repeated twice per year at minimum to maintain optimal performance (Kuduvalli, Jervis, Tighe, & Robin, 2008). Conroy, Bond, Pheasant, and Ceccacci (2010) had similar recommendations. Lammers et al. (2008) provide a summary of methodological and task-related factors that influence retention (p. 1084), and should be considered as a means of evaluating this component of simulation learning in training programs.

Students seem to develop confidence and self-efficacy when using simulation technology for learning. A quasi-experimental study with nursing students resulted in a significant increase in confidence levels after simulation training (Bambini et al., 2009). A study with physician interns showed similarly improved feelings of self-confidence (Marshall et al., 2001). High
levels of learner satisfaction have been reported with nurses (Fountain & Alfred, 2009), physicians (Franc-Law et al., 2010; Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Takayesu et al., 2006; Weller et al., 2004), and RTs (Hoadley, 2009), when simulation technology is used within health care education.

**Future Uses**

RTs receive little to no training in aspects of end-of-life scenarios, despite frequently caring for dying or palliative patients and having responsibilities on code blue and trauma teams. Often, during decisions to withdraw life support or after a patient is pronounced dead, the RT is the caregiver who turns off the ventilator or removes the artificial airway during the last moments of life. Although they are not responsible for informing family members of the death, they frequently witness extreme episodes of anguish in emergency rooms or intensive care units, and answer respiratory–related questions at the bedside from grieving family members. Simulation may provide an effective way to experience these episodes in a safe environment, with debriefing to discuss roles and feelings caused by these stressful transitions (Gaba et al., 2001; Smith-Stoner, 2009).

Simulations of challenging environmental conditions would be beneficial in an RT training program. RTs are often involved in the intra- or inter-hospital transports of critically ill patients, and this environment poses particular problems to quality care (i.e. helicopter noise interfering with auscultation, resuscitation in small elevators, accidental loss of lines or tubes during stretcher movement). Posing some of these critical scenarios during simulation would allow the RT an opportunity to use critical judgment to troubleshoot these situations (Brindley et al., 2008).
In 2008, a group of simulation experts from the Academic Emergency Medicine Consensus Conference came together to hypothesize about the future of simulation (Bond et al., 2008). Although the colloquy was focused specifically on the use of simulation to development individual expertise in emergency medicine, their dialogue and resultant paper could be applied to the future of simulation in general. Topics introduced in the discussion included the use of simulation to:

1. Learn from experts, improving clinician competence quickly.
2. Generate optimal teaching strategies.
4. Enhance real-world application.

Their conjecture lays the foundation for future research in simulation technology for health care professionals. A renowned leader in simulation, David M. Gaba (2004) succinctly describes what will be the driving forces for integrating this technology into health care including schools, professional societies, accrediting and licensing organizations, simulation societies, health care organizations, medical care funders, liability insurers, and levels of government or the public. Many of these include aspects of patient safety, improved learning mechanisms and cost savings. Among his key messages is the overarching recommendation, “systematic training and assessment of health care personnel should become a major priority of the health care system” (Gaba, 2004, p. i9).
Methodology

Research Design

In a social constructivist worldview, a phenomenon needs to be described within a particular period to interpret the construction of meanings for the individuals involved (Creswell, 2009). The assumption that this interpretation of social reality is specific only to the participants being studied during that time fits the choice of a case study for this research, where the context plays an important role in creating meaning for the participants. A case study is a qualitative research strategy that empirically describes a phenomenon when the research question asks how or why, when participant behaviour does not need to be controlled (as would be necessary during an experimental study), and when the participant is contemporary (not historical) (Yin, 2009a).

I chose a descriptive research design (as described by Edwards, 1998) to “provide a ‘picture’ of a phenomenon as it naturally occurs” (Bickman & Rog, 2009, p. 15). The purpose of this research was not to study the effect of an intervention or to create new knowledge through experimentation, but to describe in detail the existing use of technology within one institution. VanWynsberghe and Khan (2007) define the case study as “a transparadigmatic heuristic that enables the circumscription of the unit of analysis.” In this case, the unit of analysis was the TRU RT program, and the concept to be studied was the use of simulation technology, bound by pedagogical theory and empirical evidence for use in education and evaluation.

Unit of Study

Choosing an extreme case (one that stands out from like cases as high-performing or having a unique characteristic) can yield richer information than using a representative sample or randomly selecting a program (Henry, 2009). RT graduates of TRU were awarded the Canadian Society of Respiratory Therapists’ (CSRT) gold and silver medals (for first and second highest
academic marks on the national exam) in 2007. The TRU Program Chair was quoted as saying, “Our students’ average mark for the exam is 13 per cent higher than the average score of all students in the country” (Sheets, 2008). In 2008, 2009, and 2010, the gold and bronze CSRT medals were likewise awarded to TRU graduates. The use of medical simulation placed within the context of a rigorous academic program with excellent student performance provided a compelling lens in which to explore a focused analysis of the availability and use of this technology.

I selected the TRU program as a single unit for the case study. The use of a multiple-case design would have formed an interesting comparative analysis, but this idea was rejected due to the time constraints around the thesis deadlines. Further rationale for the choice of this program was the potential to provide me with detailed data during the course of the research. I anticipated that my relationship with the program as an alumna (in 1995) as well as continued links with the director and faculty in the course of my employment as a leader in the profession would provide me with open access for detailed data collection. I was aware that I would have valuable insight in how TRU students learned during their clinical year, as my job duties included providing support for third year students on placement at Vancouver General Hospital. In addition, the relatively close proximity of the university to my home (366 km) made it a reasonable choice in terms of distance for travel.

**Research Questions**

This study was primarily designed to answer the question, ‘How does the Thompson Rivers University respiratory therapy training program use simulation technologies?’ The intent was to provide a complete description of the technologies in use, and to investigate how they were being used. Andragogy formed the theoretical framework for this study, and inquiry into
learning theories used for teaching or evaluation with simulation technology became a secondary focus for the research.

**Theoretical Framework**

The use of theoretical frameworks is a key part of descriptive case studies, and helps to identify the parameters necessary for a complete and accurate description of the unit to be explored. Without the identification of the theoretical framework a priori, a descriptive case study becomes an exploratory one (Yin, 2003, p. 26). Exploring the literature helped to determine specific learning theories that were often used or recommended for use with simulation technology in health care training programs, and this formed a basis for the investigation. Questions specific to these theories were then incorporated into the interview and observation guides before data collection, and are reported in the Results section. The most prevalent learning theory reported in the literature (deliberate practice) was held as a pattern to which the results were compared during analysis. Other learning theories were also investigated and used in the development of alternative or rival explanations.

**Participants**

Purposeful sampling was used to select participants for study within the program. This sampling technique differs from random probability sampling in that it is not used as an estimate of the total population to be studied, rather it is used to select “members of the study population that are intrinsically interesting or important for the study” (Henry, 2009, p. 79). An initial discussion with the program director identified which of the seven didactic faculty members were teaching with simulation technology, and four were selected who might yield the most information. Multiple faculty members were selected for interviews to mitigate some of the problems with this data collection technique, including the possibility of receiving filtered or
incomplete information (Creswell, 2009, p. 179). The program director was also included as a key participant (sometimes known as an ‘elite’ interview, as this role is singular within the organization (Yin, 2009b, p. 264)), adding valuable information from the historical context of simulation use in the program and the vision for the future. All students in the first two years of the program were approached for consent to provide the greatest number of participants for the lab observations. Of the students who consented to participate, names were drawn to form small groups for the discussions. One adult hospital clinical placement site (Royal Columbian Hospital, New Westminster, BC) and the only pediatric site used for clinical placement (BC Children’s Hospital, Vancouver, BC) were selected to investigate how simulation was used for training with both patient populations in the third year of the program. One clinical faculty member at each of these hospitals was selected for study (those having most contact with the students in full-time positions) along with a small group of third-year students.

**Ethical Considerations**

To ensure the research met with ethical standards, I first completed the *Interagency Advisory Panel on Research Ethics’ Introductory Tutorial for the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*. Applications for approval for research with human participants were first sent to research ethics boards at Royal Roads University and TRU. Data collection at the hospital sites requires a staff physician as Principal Investigator to oversee the research, so I approached physicians who had some relationship with the RT departments to assist with the applications to the ethics boards at Fraser Health Authority and BC Children’s Hospital. These physicians did not have a direct role in my research but were kept informed about the data collection that was taking place when I was at the hospital sites. Students on clinical placement at BC Children’s Hospital travel to Vancouver General Hospital to use a high-
fidelity simulator at the Centre of Excellence for Simulation Education and Innovation (CESEI), so approvals were additionally sought from the Vancouver Coastal Health Research Institute. Permissions were obtained from the RT program director at TRU, the RT practice leaders at both hospital sites, and the program director at CESEI.

All research participants were given an invitation to participate in the study through information letters and consent forms (see sample, Appendix B). Consent forms for the one-on-one interviews were mailed to the program director for distribution among the faculty members. Data collection was arranged at TRU over a four-day period to coincide with the optimal time to observe first- and second-year students using simulation in their clinical labs. After my arrival in Kamloops, the TRU faculty provided me with time to come into their classrooms to speak directly with the students, explain the purposes of the study, answer questions and review the consent forms. Forms were then collected the following day, so the students had an opportunity to think about participation before agreeing.

Participants were advised of the benefits of participating; the students would have an opportunity to observe the qualitative research methodology process, which may provide benefit in their future professional development. Publications resulting from my research would inform the RT community about simulation use for education and evaluation, and may have direct benefit to the TRU program in identifying gaps or strengths during curriculum review. Participants were made aware what the time commitments were to take part in the study. Due to my position as a leader with the largest employer of RT students in the Province, I avoided a coercive effect by making it transparent to students that their choice of participation would have no positive or negative effect on hiring within the Vancouver Coastal Health Authority. Space was provided on the forms to include the participant’s email address, so that a final copy of the
thesis could be shared after completion.

Although confidentiality was carefully protected through use of assigned study codes instead of names, the program director and faculty were made aware that they may be identified by title, potentially allowing some people in the RT community to learn their identity. This was made explicit on the consent forms, and reviewed with the participants at the beginning of each interview. The interview participants were aware they had the right to withdraw from the study at any time up to the point when data analysis began. The master code list, in addition to copies of all consent forms and data files, were stored on a password-protected personal computer drive, and kept within my locked office. The data will be kept for a period of five years before being destroyed.

**Researcher Bias**

The complete elimination of my preconceptions, values, and theories prior to undertaking this research is likely an impossibility, and therefore it is important to disclose and communicate potential bias and discuss how this may effect the results and interpretation of the study (Maxwell, 2009). As an RT alumna of TRU and with ongoing professional relationships with the director and faculty, I am predisposed to want to portray the program in a positive light. I attempted to mitigate this by being cognizant of reporting results in an objective and factual way, and to reduce the influence of this bias in my interpretation by actively investigating alternate explanations for my findings.

Before beginning this research, I reflected on my personal views and opinions in the use of simulation technology for education in my profession. I realized it has been 15 years since I graduated, and during that time, I have not been aware of the specific equipment or methods used for teaching within the first two years of the TRU program. Without a good understanding of the
current state, I had not formed specific opinions as to how simulation technology should be used for RT training. With this consideration, I felt I could cleanly describe the way in which simulation was used, and my conclusions would be drawn directly from the analysis without influence.

I was aware that with a generic descriptive case study I might not find a strong conclusion to report. I therefore chose to focus my research questions around theoretical frameworks based on learning theories used with the technology. With a focus on learning theory and using pattern-matching methodology, I could compare and contrast the findings with the literature and report conclusions based on the presence or absence of a match, generating reader interest in those results. Using a conceptual framework also helped me to design my interview and observation guides to look for alternate explanations from the outset of data collection, further reducing the potential for researcher bias.

Data Collection

Multiple sources of evidence were used to corroborate facts (see Table 1), a process called *triangulation* used to increase validity in qualitative research (Bickman & Rog, 2009, p. 22). Focused interview methods were chosen with the program director and all didactic and clinical faculty members. Interview questions followed a guide (see sample in Appendix C) and were open-ended, allowing me to ask probing questions when necessary and encourage participant elaboration or diverging inquiry. The interviews took place in private office settings for confidentiality and ambient noise reduction, and audio recordings were made using at least two devices to ensure data were protected from accidental loss.

I anticipated that my job title could make it intimidating for students to talk with me independently. Rather than one-on-one interviews with the students, small discussion groups
were arranged to lessen feelings of nervousness or anxiety. This affected confidentiality, as the students were participating in research as a group, but reduced stress and provided an open atmosphere for dialogue. These open-ended group discussions were held with participants in each of the three years of the student program and audio recordings were made using the same methods described for the one-on-one interviews. High-resolution digital photographs were taken of all simulation technology in use across all three years of the program. Lab manuals for courses that included instructions for practice with simulation technology were gathered and used in analysis, and reports and documents were collected from the website of the national RT society.

Visual observations in lab settings were used to collect information on how the simulation technology was used by the first- and second-year students, and repeated at the hospitals for third-year students on clinical placement. Observation guides were created to provide structure to the time spent in the labs (see sample, Appendix D). Due to delays in ethics board approval, I was not able to observe third-year students using simulation technology for pediatric populations; however, I was able to observe a third-year student learning with simulation in the adult hospital placement site. These observations were invaluable to understand how the simulation technology was used in context. During these observations, I was a mute presence in the room and did not interact with the students with the intent of allowing the interaction between the student and technologies to take place as naturally as possible and avoid becoming an intrusive disturbance, a common limitation with this data collection technique (Creswell, 2009, p. 179). Students and faculty who had consented to participate in the study wore brightly coloured stickers to identify them, and field notes were taken only on those participant’s movements and actions.
Table 1.

Summary of Data Collection Process.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Selection method</th>
<th>Total number in program</th>
<th>Number selected</th>
<th>Site</th>
<th>Data collection method</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program director</td>
<td>Key participant selected for overall knowledge about the program</td>
<td>1</td>
<td>1</td>
<td>Thompson Rivers University</td>
<td>Open ended, one-on-one focused interview</td>
<td>58 min.</td>
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<tr>
<td>Didactic faculty</td>
<td>Purposeful sampling based on use of simulation technology</td>
<td>7</td>
<td>4</td>
<td>Thompson Rivers University</td>
<td>Open ended, one-on-one focused interview</td>
<td>54 min.</td>
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<tr>
<td>Clinical faculty</td>
<td>Purposeful sampling based on patient population and hospital site</td>
<td>9</td>
<td>2</td>
<td>Royal Columbian Hospital and BC Children’s Hospital</td>
<td>Open ended, one-on-one focused interview</td>
<td>50 min.</td>
</tr>
<tr>
<td>Lab manuals</td>
<td>Courses incorporating simulation technology</td>
<td>N/A</td>
<td>4</td>
<td>Thompson Rivers University</td>
<td>Scanning relevant pages</td>
<td>11 pages</td>
</tr>
<tr>
<td>Reports and documents</td>
<td>As needed</td>
<td>N/A</td>
<td>3</td>
<td>Canadian Society of Respiratory Therapists</td>
<td>Scanning relevant pages</td>
<td>3 documents</td>
</tr>
<tr>
<td>Simulation equipment</td>
<td>All simulation technology in use across three years of the program</td>
<td>37</td>
<td>37</td>
<td>Thompson Rivers University, Royal Columbian Hospital and BC Children’s Hospital</td>
<td>Digital photography</td>
<td>65 photos</td>
</tr>
<tr>
<td>First-year students</td>
<td>All participants who signed consent</td>
<td>75</td>
<td>17</td>
<td>Thompson Rivers University</td>
<td>Direct observations</td>
<td>3 hours</td>
</tr>
<tr>
<td>First-year students</td>
<td>Names drawn from</td>
<td>5</td>
<td></td>
<td>Thompson Rivers</td>
<td>Discussion group</td>
<td>38 min.</td>
</tr>
</tbody>
</table>
All field notes were typed, relevant document pages scanned, and digital photographs downloaded so that all data were converted to digital copy for analysis. Audio recordings of the interviews and discussion groups were transcribed. I transcribed approximately half of the recordings; the rest of the work was contracted out to transcriptionists. The recordings were converted from digital files or tapes to word documents through the transcription process, and then saved as plain text files for importation into the analysis software. Both transcriptionists assisting with this work signed research agreements to protect the confidentiality of the data, and destroyed their copies of the recordings and files after contract expiry. All documents were encrypted prior to electronic transfer. Transcriptions of the one-on-one interviews were sent electronically to all interview participants, who reviewed and approved the files. This process added to the reliability of the evidence by clarifying meaning and decreasing the likelihood of inaccuracies from transcription errors. It also contributed towards the development of a trusting relationship with the research participants.

Data Analysis
The data analysis was divided into two distinct phases. Phase one began with a process for sorting and organizing the data. HyperRESEARCH™ software was used to open all source files, including scanned pages, images, and text files. Codes (similar to keywords or tags) were added to paragraphs, words, ideas, or images. I used a combination technique (Creswell, 2009, p. 187) for developing them; some codes were pre-existing and identified during the literature review stage, others emerged naturally during the data analysis. A variety of recommended code types were used, as recommended by Bogdan and Biklen (as cited in Creswell, 2009, p. 187). These included setting and context codes, perspectives held by participants, participant’s ways of thinking, process codes, activity codes, strategy codes, and relationship or social structure codes. To increase validity and to ensure the definition of the codes did not drift during the prolonged analysis phase, codes were clearly defined as they were created, and definitions stored within the software program for reference. The data analysis software allowed the generation of code frequencies (Appendix E) and specific reports, allowing an in-depth qualitative analysis. As the codes were reviewed and studied, general themes emerged and codes were organized using a code map with themed headings (Appendix F).

Phase two was designed to make meaning of the data and identify relevant findings. An analytic pattern-matching technique was used specifically to find and compare the predominant learning theory used with simulation technology in the program. Pattern matching is a desirable technique for analyzing case studies (Yin, 2009a, p. 269, 2009b, p. 136), and descriptive cases can utilize this method by identifying specific variables for comparison prior to the data collection. Thus, the theoretical components of the deliberate practice model for learning with simulation (see Table 2) were specified within the literature and incorporated into the interview and observation guides. The empirical investigation was then compared with the existing
theoretical framework, and used as evidence to determine how RT students were using simulation technology for learning in the program.

Table 2.

*Conceptual Components of Deliberate Practice Theory.*

<table>
<thead>
<tr>
<th>Deliberate practice component</th>
<th>Supporting citation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained repetition and refinement</td>
<td>(Ericsson, 2004, 2008; Kneebone, 2005; Kneebone et al., 2004)</td>
<td>Repeating a task-based psychomotor skill frequently and for a sustained length of time.</td>
</tr>
<tr>
<td>Goals for learning and improving</td>
<td>(Ericsson, 2008; Kneebone et al., 2004)</td>
<td>Motivation for learning and improving present in the form of specific goals.</td>
</tr>
<tr>
<td>Reflection</td>
<td>(Ericsson, 2008; Kneebone et al., 2004)</td>
<td>Focused reflection on performance.</td>
</tr>
<tr>
<td>Progressive stages or scaffolding</td>
<td>(Ericsson, 2004; Kneebone et al., 2004)</td>
<td>Learning follows a progression from learning the steps of a skill, to being able to perform the steps, to being able to perform the actions autonomously.</td>
</tr>
<tr>
<td>Overlearning</td>
<td>(Ericsson, 2004, 2008; Johnson, 2008; Kneebone, 2005)</td>
<td>Additional practice or application to a clinical setting soon after gaining initial proficiency in a simulated setting.</td>
</tr>
<tr>
<td>Expert guidance</td>
<td>(Ericsson, 2004; Kneebone, 2005; Kneebone et al., 2004)</td>
<td>Knowledgeable expert available or supporting autonomous work depending on learner needs.</td>
</tr>
<tr>
<td>Debriefing</td>
<td>(Ericsson, 2008; Kneebone et al., 2004)</td>
<td>Specific and immediate feedback for student following skill observation by instructor.</td>
</tr>
<tr>
<td>Positive environment</td>
<td>(Kneebone, 2005)</td>
<td>Affective learning component includes a positive, motivational, and respectful learner-centered environment.</td>
</tr>
</tbody>
</table>
Results

The data collected through interviews, discussion groups and observations as well as documents and reports were structured to provide information on key themes related to the research question; “How does the Thompson Rivers University respiratory therapy training program use simulation technologies?” Analysis was phased to include sorting and organization followed by recognition of patterns and meaning. The results begin with a description of the history and evolution of simulation use in the program, adding a contextual element to the findings. Although the rationale for using simulation in medical training is clear within the literature, additional evidence is provided in the results for justification of its use in this program. The simulation technology is then categorized and described in terms of physical, environmental, and psychological fidelity. Learning theories are identified and the application of the technology is explored. The advantageous and beneficial aspects of simulation use in the program are illustrated, followed by evidence for detrimental aspects or challenges with use.

History and Evolution

The current program director has been working in some capacity within the TRU program for 18 years, lending credibility and knowledge to the statements on the evolution of simulation use and descriptions of key drivers for change. Simulation technology has been used in the TRU RT program since its inception, with the first graduating class in 1982. The director stated, “I was a student in the program in the early to mid eighties and certainly there was low-fidelity simulation used at that time and has continued to be used”. The test lungs have likely been in existence for the longest period, and the design has not changed dramatically since that period. In terms of sophistication, both part task trainers and high-fidelity simulators have evolved to keep up with new computer technology. The program director reported that the key
driver for acquiring increased numbers of simulators over the years has been the gradual increase in student intake, in order to keep an appropriate quantity available for use in the clinical lab environments. A changing scope of practice, accreditation, and patient safety were described as additional drivers for increasing the overall use of simulation technology in the program. Two of the didactic faculty and one of the clinical faculty members have had some training in teaching with simulation.

**Rationale**

High-risk procedures, low-frequency skills, and patient safety were all frequently cited within the code map frequency report (Appendix E), providing strong evidence for identifying these as the top reasons for simulation use in this program.

A large proportion of the entry-level RT competencies, as reported in the 2003 National Competency Profile (National Alliance of Respiratory Therapy Regulatory Bodies, 2003) are considered to be *restricted activities*; defined by the BC Ministry of Health (“Health Professions General Regulation Restricted Activities,” 2010) to have the potential to cause significant patient harm. The need to acquire skill in high-risk activities was the most frequently reported rationale for use of simulation in the TRU RT program, and was referred to by all of the interview participants and during all of the discussion groups with the first-, second-, and the third-year students. Students repeatedly voiced their feelings of responsibility to protect patients from harm when using life-supporting equipment or performing life-saving procedures. For example, one first-year student said “I think the goal of simulation actually is to nullify fears and anxieties that we all have, I’m sure, of going in there and having patient’s lives in our hands…if you messed up, someone could die.” Some examples of high-risk activities that simulation was used for
included arterial blood gas punctures, arterial cannulation, mechanical ventilation, intubation, tracheostomy tube changes, tracheal suctioning, and central line insertion.

High-risk procedures that are encountered with low frequency when working as an RT were additionally pointed out as a good rationale for training with simulation technology. These would include assistance with surgical airways such as cricothyroidotomy and other advanced airway techniques. Faculty pointed out the benefits to using simulation to improve the consistency of exposure to procedures that students may not always encounter during their clinical placement. “One of the challenges that we face in the clinical teaching environment is that it’s hard to know that all of our students have had a consistent experience”, explained one clinical faculty member. Another described the benefits to using simulation in the student rotation at BC Children’s Hospital for recreating scenarios of a neonatal respiratory disorder that is life-threatening but rarely seen; “for us to build a simulation based on that is invaluable to them because the one time they do see it, they might be able to remember and respond appropriately to it”.

Patient safety was frequently cited as a rationale for use of simulation technology. Second-year students run a sleep disorders clinic to gain experience in patient assessment techniques, and before performing skills on real patients, they are required to demonstrate proficiency in these techniques on a simulator, “anything they’re going to do on a patient in the clinic, they have to have shown us” (didactic faculty member). Using simulation to train students was also identified as an ethically sound principle, as this faculty member describes, “I think ethically…if we can simulate that environment prior [to entering clinical year], then we can say that we’ve taught them and evaluated them and said that they’re safe to do these procedures in as close to a realistic environment as possible”.

In assessing the need for high-fidelity simulators in the second year of training, the program director stated, “The clinical environment is still the best context-specific area for them to develop clinical competence, and so it’s going to be a matter of where do we bridge that, how much high-fidelity do they need…prior to going into clinical year, to maybe make it less risky for patients”. A first-year student described how training with simulators allowed for a culture of permissible errors for learning, “if you’re making a mistake in learning how to do it the first time, then it is best to be doing it on something that has no consequences”. This student went on to describe those potential consequences as death or injury. A second-year student agreed, and felt reassured that faculty members were constantly watching them and would notice and correct errors in simulation before they resulted in adverse patient events.

Simulation Equipment

The TRU RT program uses a full spectrum of part-task trainers, torsos and full-body mannequins. It is an almost-ghoulish parade of body parts, following a complete typography from low- to intermediate- to high-fidelity technology. Examples of the low-fidelity simulation technologies (part-task trainers, see Figures 1 through 5, torsos, see Figures 6 through 9, and full-body mannequins, see Figures 10 through 13) are shown in the photographs below. In many cases, the program owns more than one of each item. Some of the equipment is owned by the hospitals, but is shared openly and accessible by students on clinical placement at those sites. The bulk of simulation technologies owned by TRU were low-fidelity systems used within the clinical lab settings for students in the first two years of the program. The low-fidelity systems included adult, pediatric, and neonatal models. Covered with rubber skin, they were generally made to resemble parts of or complete human bodies.

Low-fidelity part task trainers.
Figure 1. Hand used to learn how to palpate a radial pulse.

Figure 2. Upper airway anatomical model.
Figure 3. Cross sectional upper airway anatomical model with moveable jaw.

Figure 4. Upper airway anatomical model cutaway.
Low-fidelity torsos.

Figure 5. Cross sectional upper airway anatomical model with tracheostoma.

Figure 6. Neonatal intubation head with inflatable balloon lungs.
Figure 7. Tracheostomy torso.

Figure 8. Pediatric CPR torso.
Low-fidelity full-body mannequins.

Figure 9. Intubating torso with inflatable lungs.

Figure 10. “Cabbage Patch Kids®” used as neonatal trachesotomy trainers.
Intermediate-fidelity trainers include items that require an instructor to create a physiologic change in response to the student’s care. For example, with the rubber arms (see Figure 14), the instructor squeezes a bulb to create a pulse under the skin, and with the test lungs,
the instructor can manipulate the tension on the devices to mimic physiological changes. The lung simulators were the least likely to have realism in human anatomy or proportions, but were some of the most technologically advanced in replicating human physiology, as they allowed dual manipulations of lung compliance and lung resistance. In some cases, this was accomplished through rotating a dial, or adding/removing a spring (see Figures 15 through 18).

For the second-year student labs, two test lungs were banded together and connected to two ventilators, called a master and slave (see Figure 19). The slave ventilator pushed open one test lung, which pulled open the other, ingeniously simulating a spontaneously breathing patient for the master ventilator. This allowed the student to practice using spontaneous modes of ventilation.

**Intermediate-fidelity part task trainer.**

*Figure 14.* Rubber arm with simulated blood bag.
Intermediate-fidelity lung simulators.

Figure 15. Neonatal double-lung simulator.

Figure 16. Adult and neonatal single lung simulators. These are non-adjustable, and would be classified as low-fidelity systems.

Figure 17. Lung simulator with adjustable compliance (springs) and resistance (restrictor dial).
Figure 18. Lung simulator capable of fine physiologic adjustments.

Figure 19. “Master-slave” lung system for simulating spontaneous ventilation.
Intermediate-fidelity torsos.

The intermediate-fidelity torsos used in the program ranged from simple technology, where the instructor could create arterial pulsations during CPR training (see Figure 20), to advanced remote-controlled technology where respiratory rate, oxygen saturation, jaw stiffness, tongue edema, and laryngospasm could be simulated to provide advanced airway management training (see Figure 21).

*Figure 20.* Pediatric CPR trainer with simulated pulse.

*Figure 21.* AirMan® torso designed to simulate airway emergencies.
**High-fidelity full-body mannequins.**

The high-fidelity systems available for the students included an adult mannequin housed in the clinical lab at TRU (see Figure 22), a neonatal mannequin available for use at BC Children’s Hospital and CESEI at Vancouver General Hospital (see Figure 23), and a pediatric mannequin at CESEI. These systems were fully programmable for virtually any medical scenario. The mannequins were interactive, providing immediate feedback to students during the scenario and featured realistic vital signs with pulses, breath sounds, and even pupillary reactions. Both models featured interchangeable skin so that surgical incisions could be made and cannula inserted repeatedly. These dolls had a detectable cardiac rhythm, respiratory rate, and oxygen saturation when connected to a cardiac monitor, and could simulate airway emergencies by altering laryngeal anatomy.

*Figure 22. SimMan® high-fidelity adult full-body mannequin used at TRU.*
Computerized simulators.

Computer simulators used in the program included interactive compact discs supplied by some of the mechanical ventilator manufacturers, made available for the students to sign out for review. One of the didactic faculty members had arranged a subscription to ProceduresCONSULT (www.proceduresconsult.com), an online repository of video and animated procedures available for viewing. The second-year students were able to access this website from home and review the videos prior to practicing them in the lab. Also available were defibrillation simulators (see Figure 24), digital devices for simulating breath sounds during auscultation (see Figure 25), and ECG tracings (see Figure 26). A custom-built pharyngeal simulator developed as part of a research project to simulate sleep disorders for testing noninvasive ventilators was also situated in the clinical lab (see Figure 27). Although typically, simulation typology describing computers pertains to interactive online scenarios (Bradley,
2006), the computerized simulators shown below are included under that heading as they are used primarily to simulate human physiology.

*Figure 24. Defibrillation simulator.*
Figure 25. Breath sounds and cardiac rhythm simulator.

Figure 26. Cardiac rhythm simulator.
Virtual reality.

Virtual reality systems (using a complex computer-generated image, sometimes combined with tactile senses) were not in use in the TRU RT program.
Simulated patients.

The use of simulated patients was widespread throughout the first two years of the program, and the patients used in this simulation technique varied considerably. In some cases, the students acted as their own patients. They were encouraged by faculty members to take home equipment such as noninvasive ventilators, pulse oximeters, and blood pressure monitors to self-apply and become proficient in setups and use of the machines before using them on real patients in their outpatient clinic. A secondary purpose for doing this was to experience therapies as a patient would. During my observations of the first-year students in their instrumentation lab, I recorded these field notes; “One student was learning to use a turbohalers – an asthma medication delivery device – by holding it in front of his mouth, then inhaling and holding his breath as if he was the patient”. Third-year students also reported learning by connecting themselves to a mechanical ventilator using a mouthpiece, nose clips, and circuit.

The most common use of simulated patients was with other RT students. During the labs, the students generally worked in small groups of four to six members, and many of the non-invasive skills were practiced on a partner. In some cases, the students used a combination of part-task trainer and simulated patient, such as they did when learning arterial blood gas punctures. Guided by the steps listed in the lab manual (Thompson Rivers University, 2009a, p. D9), students first introduced themselves to their partner, explained the procedure, checked pulses, and performed a vascular assessment test. They would then use the rubber arm to gain arterial access with a needle and syringe. Other forms of simulated patients included the faculty members, who would sometimes have the students demonstrate procedures on them such as vital signs, so they could closely monitor the placement of the stethoscopes and the pressure inside the blood pressure cuff.
The use of simulated patients seemed to have some clear advantages over mannequins. Applying patient interfaces for oxygen therapy was much more realistic when dealing with facial hair, slippery skin, and people sitting in an upright position rather than plastic mannequins lying flat on a table. Observing patterns of nebulized gas flow was possible in a real person during inhalation and exhalation.

However, the mannequins also had some advantages over use of simulated patients in a learning environment, as this first-year student described; “the patients forget they are the patients and they start trying to help you, start giving you their opinion where the doll just sits there and you can do your own thing and figure it out for yourself”. Another student thought they learned more watching their partner use the mannequin than they would have if they were acting as a patient.

Simulated patients sometimes did not exist at all. In instrumentation lab, one first-year student was holding a pediatric asthma medication delivery device in his hands, and was trying to determine how to use it. While puffing the medication, he made the sound of a baby crying to simulate an imaginary pediatric patient.

Imaginary patients were also often used with third-year students. The instructor would take them into a hospital room, and ask them to prepare equipment or verbalize admission for a fictitious patient.

Vignette 1. Imagine all the people...

Interdisciplinary work was demonstrated with the use of students from other programs as simulated patients. In the first year of the program, the RT students collaborated with others from the early childhood education and nursing programs to demonstrate how to use asthma medication delivery devices. In third year at BC Children’s Hospital, high school students were used as simulated patients when a local secondary school was asked to take part in a mass
casualty trauma simulation. They were coached in their fictitious injuries and applied with makeup to act out events as part of an annual disaster response practice scenario. Third-year RT students took part in this scenario, helping to triage and treat patients with chest injuries or respiratory distress.

The simulated patients could also be complete strangers by intent. The faculty recognized the importance of having students learn to talk to patients in a professional manner, and to overcome the anxiety that can come with entering the personal space of someone they do not know. For the patient assessment training in the second year of the program, first-year students, friends, and even family members are sometimes recruited to act as a patient.

Real patients are occasionally used in simulation. Within the second year of the program, clients who have been through the sleep diagnostics clinic may return to allow other students to repeat assessments on them. This technique is known as the use of expert patients. Real patients can also be used for simulation purposes without making this explicit; in the third year of the program, students who are new to an area may practice assessing a critically ill patient who is actually under the care of another therapist, recording vital signs, and ventilatory parameters on a practice flow sheet. In one adult hospital, the clinical faculty described how students are asked to listen to handover report from the staff therapists; “what we’ll do is have them listen to the full report, and then when the staff RTs have left the room, have them pretend to give report to a group but in actual fact they’re giving it to us”.

Environmental Fidelity

Described by Beaubien and Baker (2004, p. 152) as “the extent to which the simulator duplicates motion cues, visual cues, and other sensory information from the task environment”, environmental fidelity is used to enhance learning with simulation in the second and third years
of the program. Although the clinical lab setting at TRU where all the hands-on learning takes place does not resemble a hospital environment, some attempts were made at creating realistic visual representations. When second-year students were training for neonatal resuscitation, an infant low-fidelity mannequin was placed in an overhead warmer and surrounded by resuscitation equipment that would normally be found during a delivery (see Figure 28). When setting up a high-fidelity simulation for second-year students, the faculty members moved equipment around in the lab and set up partition walls (see Figure 29) to recreate a hospital room. The faculty, in describing the challenge of creating environmental fidelity in the lab, expressed frustration at not having adequate space to do this effectively and indicate they “try to do as much as possible with what we have”.

Figure 28. Neonatal low-fidelity mannequin placed in overhead warmer to enhance environmental fidelity.
During third year, the students on clinical placement at BC Children’s Hospital had access to a high-fidelity neonatal simulator placed within a recreated hospital room. This simulator is also portable, and was taken throughout the hospital for *mock code blue*; impromptu resuscitations that were arranged at any empty hospital bedside. The nurses working on that unit and the code team (including the RT students) were expected to attend each mock code and treat it as though it were real, using the real resuscitation equipment available in that room and on that ward. The pediatric simulator at CESEI was similarly placed in a recreated hospital room to enhance environmental fidelity.

**Psychological Fidelity**

Further to fidelity of the equipment and environment, psychological fidelity is the “degree to which the trainee perceives the simulation to be a believable surrogate for the trained task” (Beaubien & Baker, 2004, p. i52). The low-fidelity part-task trainers used within the TRU program often did not lend well to creating a believable scenario: It would have been difficult for
anyone to suspend disbelief when working on a mannequin with no arms (see Figure 13). In some cases, however, steps were taken to improve psychological fidelity in the lab setting. For example, much of the mechanical ventilation training involved lung simulators, which have no human likeness (see Figures 15 through 19). One student was even observed to use the toe of her shoe to methodically push open the lung simulator in an attempt to simulate spontaneous breathing. A faculty member described a process by which ventilator tubing was rerouted to go through a mannequin’s chest before connecting to the lung simulator, so that the students would see a patient attached to their ventilator. It was explained this was done occasionally to reduce unprofessional behaviour that can occur when therapists become focused on the ventilator and forget a patient may be listening to conversations occurring at the bedside.

The faculty did recognize some benefit in creating psychological realism. In describing how the students sometimes learn patient assessment skills on strangers or expert patients rather than each other, one didactic faculty member said “they know it’s not real with a student, right, and so there’s a bit of difference between how much they get out of it from an emotional point of view”. The clinical labs during the first two years of the program contained many instances where students were encouraged to treat the mannequins or simulated patients as if they were real. For example, students were using sterile gloves and wearing goggles when cannulating an artery on a rubber arm, as if there was a real danger of occupational exposure. They used tape to secure the line as if they expected patient movement. However, the intent behind this was not to encourage students to truly believe the simulation technology was real, but to include steps such as “introduces self and explains procedure to the patient” (Thompson Rivers University, 2009b) so the sequence of cognitive steps would be complete when students replayed it in a clinical environment. This rationale was explicit during an interview with one didactic faculty member;
“With the part task trainers I don’t think there’s that immersion occurring. It’s more the step by step, you know, being able to do things safely, a correct routine. Yeah, the immersion I don’t think occurs at that level. Not with those part task trainers anyways it’s very difficult, especially with everything else that’s going on around them. They need to be in a room, simulated environment and then you might get some more of that buy-in. I don’t think that occurs in the lab setting”.

The students, however, described how they would attempt to try to immerse themselves in the scenarios to affect a degree of realism. They repeatedly discussed the benefits of having faculty create verbally intense pressure situations for them to practice within, to gain comfort levels in emergency scenarios as well as to increase their confidence with patient interactions. First-year students stated how use of simulated patients allowed a greater sense of psychological realism;

“When it is another student being a patient, I try and do my very best to imagine them as a patient but with the dolls, I’m just, it is basically just one piece fitting into another piece; it’s just another piece of Lego”.

The second-year students likewise attempted to create realism for themselves. They frequently made fictitious small talk with each other before the simulated patient assessments. When working with a partner in lab, one went as far as having a long conversation with his patient about how his drive to the clinic was, and asked his patient if he had any trouble finding a parking spot.
Psychological fidelity was used to ‘paint’ a more accurate clinical picture when learning emergency scenarios. At the end of the second year of the program, students begin practicing case management. The faculty use an intermediate-fidelity simulator during this course, which displays vital signs on a monitor during the scenario. They describe how the student must use the information from this monitor to “follow a time-sensitive series of interventions in order to assess, determine that the tube is terminally obstructed, urgently extubate the tube and then reintubate using video laryngoscopy”.

A time-sensitive emergency scenario was also observed to be utilized by the clinical faculty for training third-year students while on clinical placement at hospital sites. Although low-fidelity trainers were used in that scenario, the faculty member created a sense of urgency through verbal cues.

Vignette 2. Painting reality through visual or verbal cues.

In discussions with the third-year students, they indicated that when learning procedures such as arterial blood gas punctures on a rubber arm, including aspects of psychological realism would have added to their confidence level when translating that to real patients. They felt confident in the skills, but were unprepared for the patient reactions (flinching, complaining of pain, grimacing). The students indicated that using high-fidelity mannequins that had the capability of incorporating these reactions would have been beneficial, or even having faculty or other students providing the verbal cues as they practiced.

As the first-year students had not yet had an opportunity to experience high-fidelity simulation, they suggested the following methods to improve the realism of the low-fidelity mannequins: “Improve the life likeness of the dummies. Not all of them look very real. You want them to have like bulging eyes like they can’t breathe or whatever. The more human they look, the more prone I am to actually paying attention to them”. The high-fidelity mannequins used in the second and third years were detailed and interactive enough (see Figure 22 and Figure 23) that students had an opportunity to become immersed in the scenario, particularly when they were combined with environmental props. However, as the high-fidelity simulator
was not in use in the fall semester when I visited TRU and the third-year students were not scheduled to use the CESEI simulation lab during my data collection period, I was unable to observe RT students using high-fidelity simulation to gain a sense of the degree of immersion that took place.

**Learning Theories**

Interestingly, although aspects of deliberate practice theory were apparent throughout all three years of the program, none of the faculty seemed aware of this specific theoretical model. The program structure seems to have just naturally evolved over time to incorporate specific aspects of this conceptual framework, as I was unable to find specific evidence of staff knowledge around deliberate practice theory despite pointed questions in interviews with faculty members or the program director. Without exception, however, data collected during these interviews, during all student discussion groups, through collected lab manuals, and during observation sessions referenced and supported all of the components of this theory (see Table 3).

### Table 3.

*Evidence of Components of Deliberate Practice Theory.*

<table>
<thead>
<tr>
<th>Deliberate practice component</th>
<th>Participants and Source</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained repetition and refinement</td>
<td>a. Program director interview</td>
<td>a. “Cognitive domain application is what we strive for in our simulation environment”.</td>
</tr>
<tr>
<td></td>
<td>b. Didactic faculty interview</td>
<td>b. “With the mannequins they can just kind of go in cold, and they have that opportunity to do it wrong and they can do it over and over and over again until they do it correctly”.</td>
</tr>
<tr>
<td></td>
<td>c. Didactic faculty interview</td>
<td>c. “They’re redoing it over and over in the same lab - similar skills, even though they’re using different numbers”.</td>
</tr>
<tr>
<td></td>
<td>d. Didactic faculty interview</td>
<td>d. “Because the clinical lab and clinic are open until ten o’clock at night, the students are required to repeat [the procedures] to a point of close to mastery”.</td>
</tr>
<tr>
<td></td>
<td>e. Didactic faculty</td>
<td>e. “That could be in the neighborhood of six hours of...”</td>
</tr>
<tr>
<td>Goals for learning and improving</td>
<td>Reflection.</td>
<td></td>
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<tr>
<td>---------------------------------</td>
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<td></td>
</tr>
<tr>
<td>a. (Thompson Rivers University, 2009b) Lab Manual</td>
<td>a. Didactic faculty</td>
<td></td>
</tr>
<tr>
<td>b. (Thompson Rivers University, 2009a) Lab Manual</td>
<td>a. “I also see that we review this in a classroom format,</td>
<td></td>
</tr>
<tr>
<td>c. Didactic faculty interview</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Second-year student observation notes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. “The procedure is evaluated as ‘Passed’ if all 18 steps are completed in 5 min. without prompting or skipping of steps”</td>
<td>a. “The procedure is evaluated as ‘Passed’ if all 18 steps are completed in 5 min. without prompting or skipping of steps”</td>
<td></td>
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<tr>
<td>b. “The procedure is evaluated as ‘Passed’ if all 15 steps are completed in 5 minutes without prompting or skipping steps”</td>
<td>b. “The procedure is evaluated as ‘Passed’ if all 15 steps are completed in 5 minutes without prompting or skipping steps”</td>
<td></td>
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<tr>
<td>c. “Each lab is constructed so that there will be, there’s measurable objectives and the student is informed of the outcomes that we are monitoring”</td>
<td>c. “Each lab is constructed so that there will be, there’s measurable objectives and the student is informed of the outcomes that we are monitoring”</td>
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<tr>
<td>d. Objectives were clearly stated at the start of the lab.</td>
<td>d. Objectives were clearly stated at the start of the lab.</td>
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running head: playing with dolls

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<thead>
<tr>
<th></th>
<th>things that I will do based on labs will have clicker(^3) sessions to see if they’re getting some of the theoretical points important to that simulation”.</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Second-year</td>
<td>“You have two people do blood pressure on a person and say, ‘OK, what did you get’ and compare”.</td>
</tr>
<tr>
<td>student</td>
<td></td>
</tr>
<tr>
<td>discussion group</td>
<td></td>
</tr>
<tr>
<td>c. Second-year</td>
<td>Key teaching moments were highlighted by the faculty member.</td>
</tr>
<tr>
<td>student</td>
<td></td>
</tr>
<tr>
<td>observation notes</td>
<td>“Learning from theory with the lab portion at the same time just gives you a better understanding of theory too so it just ties it together better. It reinforces it”.</td>
</tr>
<tr>
<td>d. Second-year</td>
<td>All students observing the scenario were quiet until the end of the test, then they discussed positive and negative aspects of the student’s performance.</td>
</tr>
<tr>
<td>student</td>
<td></td>
</tr>
<tr>
<td>discussion group</td>
<td>After performing the skills on each other, the students would often (but not always) stop for reflection and talk about how they think they did, and what they thought they had missed.</td>
</tr>
<tr>
<td>e. Second-year</td>
<td>After the debriefing, the [instructor] had the student run through the scenario a second time to reinforce skills and ensure there were no omitted steps.</td>
</tr>
<tr>
<td>student</td>
<td></td>
</tr>
<tr>
<td>observation notes</td>
<td></td>
</tr>
<tr>
<td>g. Third-year</td>
<td></td>
</tr>
<tr>
<td>student</td>
<td></td>
</tr>
<tr>
<td>observation notes</td>
<td></td>
</tr>
<tr>
<td>a. Program director</td>
<td>“We recognize that certain events and sequencing of instruction are typically required in order to support the learner gaining knowledge to the required level of cognition”.</td>
</tr>
<tr>
<td>interview</td>
<td></td>
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<tr>
<td>b. Program director</td>
<td>“We’d also want to make sure we go through those proper stages of knowledge comprehension, application”.</td>
</tr>
<tr>
<td>interview</td>
<td></td>
</tr>
<tr>
<td>c. Didactic faculty</td>
<td>“They’d always get the background theory on it. The demonstrations are done here, we either do them first as a large group, and then in smaller groups as they get to that particular lab, and then we spend time watching them”.</td>
</tr>
<tr>
<td>interview</td>
<td></td>
</tr>
<tr>
<td>d. Didactic faculty</td>
<td>“So it goes from basically a simulation as I was saying, simulation with their partners, simulation with potentially someone they don’t know that isn’t a real patient, to a real patient, and so that’s the stages it goes through”.</td>
</tr>
<tr>
<td>interview</td>
<td></td>
</tr>
<tr>
<td>e. Didactic faculty</td>
<td>“If you don’t have a good foundation, then you’re…not going to do well”.</td>
</tr>
<tr>
<td>interview</td>
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</tbody>
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\(^3\) Clickers are handheld wireless devices used by students to respond to multiple choice questions. Real-time tabulations are available to the instructors anonymously and results displayed for the entire class.
| f. Didactic faculty interview | f. “I think we have to be very careful that we build a solid foundation, and then we get more and more and more complexity”. |
| g. (Thompson Rivers University, 2009c, p. B34) Lab manual | g. “Sequence of skill development: For optimal performance in this section of Lab ‘C’ the respiratory therapy student should develop their skills in the following order prior to attempting this lab”.
| h. Clinical faculty interview | h. “We just simulate the process without an actual patient there, and then the next stage of learning would be to assign them a patient who is already under the care of another RT, have them pretend that it’s their own patient and receive the patient themselves”.
| i. Second-year student discussion group | i. “It’s just step by step teaching us each individual part and then we’ll be able to…put it together”.
| j. Second-year student discussion group | j. “You learn something in class and it doesn’t make really good sense until you’ve done it in lab, and it is so nice that we have so many, we have labs every day”.
| Overlearning | a. Program director interview |
| a. “Classroom events and sequencing with subsequent lab activities, which then lead into the clinical application activities”.
| b. Didactic faculty interview | b. “We have to have people ready to transport their theory, lab skills, and knowledge to the clinical environment”.
| c. Didactic faculty interview | c. “When we look at some of the important skills, the airway management and the ability to intervene and provide basic airway stabilization, tracheostomy change and care, those are done immediately before they enter clinical practice”.
| d. Didactic faculty interview | d. “To try and make it so that at least you can see the practical application of what you’ve learned in theory. So that’s what I’m trying to do”.
| e. First-year student discussion group | e. “None of us have really been in a hospital setting where someone’s…life is on the line…our brain works differently under pressure so we are slowly training ourselves to think analytically under those pressures”.
| f. Second-year student discussion group | f. “It’s so drilled into you, you don’t even realize after a while…You don’t think you know what to do and all of a sudden you’re there and you just start going through a protocol” [commenting on her observations of third-year students performing skills in hospital settings].
| g. Second-year | g. “I think for ventilators, it’s something you should
<table>
<thead>
<tr>
<th>Expert guidance</th>
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</tr>
</thead>
</table>
| a. Program director interview | a. “We really support good student to faculty ratios in the lab”.
| b. Didactic faculty interview | b. “We’re always floating around watching them and see how [the students are] doing”.
| c. Didactic faculty interview | c. “We may pause the step in the procedure, provide the feedback, redirect them to that, you know, define the theory that’s relevant to that, allow them to proceed under our watchful eyes”.
| d. Second-year student lab observation notes | d. Each group repeated the exercise many times throughout the lab session, and asked for feedback from faculty members when needed. The students would reach a common conclusion and then sometimes ask for clarification. Sometimes they looked for faculty members to confirm their findings, and occasionally could not find a faculty member who was free to help them. There were two faculty members for the lab session, about four groups of students.
| e. Second-year student observation notes | e. There was some peer-to-peer learning but students had a strong reliance on guidance from the faculty members for this lab. Questions were encouraged and some one-on-one help was provided when necessary.
| f. Second-year student observation notes | f. When a group of students became confused with the assignment, the faculty member quickly stepped in to provide further demonstration.
| g. Second-year student observation notes | g. The faculty member provides guidance during the scenario, giving feedback, support, troubleshooting equipment and answering questions.
| h. Third-year student discussion group | h. “If you have somebody who is here and …constantly doing it, you know, full time, watching you and critiquing you…that is the most helpful thing”.
| Debriefing |  |
| a. Didactic faculty interview | a. “They get the feedback with the debriefing, so they can reassess; ‘OK, why did I do that incorrectly or not’”.
| b. Didactic faculty | b. “During the lab time itself they’ve always got feedback
<table>
<thead>
<tr>
<th>Interview Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Didactic faculty interview</td>
<td>“We also have performance checklists that the student and their lab partner can use”.</td>
</tr>
<tr>
<td>d. (“SimMan Description,” n.d.)</td>
<td>“Simulator utilizes software generating automatic debriefing, based on the event log synchronized with video pictures, which provide immediate, detailed feedback on performance to learners”.</td>
</tr>
<tr>
<td>e. Clinical faculty interview</td>
<td>“The only way for the student to know that they’ve succeeded in a simulation is for the preceptor or the instructor to give them feedback”.</td>
</tr>
<tr>
<td>f. Clinical faculty interview</td>
<td>“I do debrief with them immediately after the scenario has completed, they get a complete debrief with the entire team”.</td>
</tr>
<tr>
<td>g. Clinical faculty interview</td>
<td>“With SimMan of course there’s debriefing software involved in that…so it’s a little more formal debriefing they can sit down as a group and discuss what happened in the scenario”.</td>
</tr>
<tr>
<td>h. Second-year student observation notes</td>
<td>The critique the students gave each other often included suggestions for improvement or alternate methods for the skill.</td>
</tr>
<tr>
<td>i. Second-year student observation notes</td>
<td>The faculty member waited until the end of the test before providing a debriefing for the students. The debriefing lasted a few minutes.</td>
</tr>
<tr>
<td>j. Third-year student discussion group</td>
<td>“They have the doll that shows you, you know, how fast you’re going and it gives you tips like you’re not, you’re going too fast, you’re not giving enough chest recoil…it’s the feedback”.</td>
</tr>
<tr>
<td>k. Third-year student observation notes</td>
<td>When the scenario was over, the [instructor] immediately debriefed with the student. The student was asked to ‘talk her way through the scenario’ and explain the rationale behind each step that was taken. They then discussed the choices the student made and which options were successful interventions and what could have been done differently. They then reviewed a few other ‘what-if’ scenario options.</td>
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<table>
<thead>
<tr>
<th>Positive environment</th>
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<tbody>
<tr>
<td>a. Second-year student observation notes</td>
<td>The feedback was honest, respectful and was given within a positive atmosphere.</td>
</tr>
<tr>
<td>b. Second-year student observation notes</td>
<td>There was a friendly and positive atmosphere throughout.</td>
</tr>
<tr>
<td>c. Second-year student observation notes</td>
<td>It was a relaxed, fun, humourous, positive learning atmosphere with good energy.</td>
</tr>
<tr>
<td>d. Third-year student</td>
<td>The [instructor] talked throughout this scenario, giving positive and constructive feedback. Errors and</td>
</tr>
</tbody>
</table>
Throughout the discussion groups, students in all three years of the program commented on how repetitive practice was a benefit to their learning. The first-year students were not learning procedures for high-risk activities and were focusing mainly on simple respiratory equipment and the basics of mechanical ventilation, but reported they wanted more opportunities to practice. The second-year students had open access to the lab after hours, and often worked until ten o’clock at night, going over their skills and procedures until they had mastered them. They were additionally given review lab periods where they could focus on areas where they felt they required more practice. The third-year students were trying to get as much practice as possible during their clinical year but their skills were being performed on real patients – although one student said she wished there were mannequins set up in the hospital to practice on.

Lab time seemed at a premium; the first-year students felt they were not getting enough time to practice their skills. “I get a little bit worried, like in labs, that I don’t get enough time with the material or like the equipment to learn it well enough because there are so many people in each group”. “There is not a lot of time to do one-on-one, there is not enough equipment and there is not enough time”. “Everyone takes it pretty seriously because they know that you only have a couple of minutes to work with the equipment in each lab”. “I wish we had more time to do other than the three hours we have a week”. “I know that lab time is limited, but just not even so much more equipment or better equipment, just more time, like, seriously”. “If we had an open lab, I’d be in here all the time”.

In regards to learning through peripheral participation during simulation, there were several instances during the observation periods where students seemed to be learning while
watching others (see Vignette 3), and comments made during the discussions for second- and third-year students where they confirmed learning was taking place during group work. The didactic faculty members did not always believe that there was opportunity for education when students were using high-fidelity simulation in a group; however, third-year students who claimed it was valuable to watch someone else perform the simulation refuted this.

I had an opportunity to observe a patient assessment lab exam with a group of second-year students. One student was using the instructor as a simulated patient, while the others watched intently, followed a checklist, and took notes. When the test was over, the instructor turned to the group instead of the student and asked for their observations. The students then pointed out all of the things that were inaccurate or missed during the test, and suggested ways to improve or revise the techniques.

During all of the lab observations, all students in the groups seemed highly engaged and intent on learning as much as they could even though it may not have been their turn to handle the equipment. There were only a few instances where the learners would disengage momentarily to check their cell phones.

Vignette 3. Engaged learning through peripheral participation.

Virtually all of the lab environment time, which was scheduled each afternoon for the second-year students, was structured as group learning. The groups consisted of three to seven students, and they would work through their lab assignments together. The faculty member would be circulating through the groups, answering questions, and sometimes working individually with a student when necessary. There was some evidence of constructivist learning, particularly with the second-year students, as they seemed to rely less on the instructor and more on each other. When answering a question, the students would debate and seemed to naturally form a common conclusion before moving on to the next problem. The students were not hesitant in intervening when one of them was performing something incorrectly, and during my
observations, they worked to draw conclusions and create new knowledge together – although if they could not agree on an answer, they would check with an instructor.

**Simulation for Education, Evaluation, and Research**

All patient populations were covered by the simulation technology in this program, including neonates, pediatrics, and adults. The primary use of simulation technology in this program was for educational purposes. Anatomy was covered during classroom learning, and reinforced through use of simulation. For example, the students were aware of the anatomical structure of the vasculature of the arm, and when working with the rubber arms, would use that knowledge to determine where to palpate for the radial artery pulse. Another student in the group would squeeze a bulb syringe with simulated blood inside, creating a regular pulse to be used to aim the needle during arterial blood gas cannulation exercises. Students would also use each other as simulated patients to get a feel for what a real pulse would feel like, as they performed vascular assessments on each other before turning to the rubber arms for cannulation.

Much of the simulation equipment available for use at TRU and at the hospital sites were anatomical trainers: cross-sectional, dissected, or cutaway sections of upper airway anatomy (see Figures 2 through 5).

Education in physiology was also extensively supported by use of simulation technology. The lung simulators were adjustable for compliance and resistance (see Figures 15 through 19), and there were simulators for adventitious breath sounds (see Figure 25), ECG tracings (see Figure 25 and 26), blood pressure, respiratory rate, and saturation of oxygen. CPR techniques were one of the prime uses of the technology, inclusive of bag-mask ventilation (see Figure 6 and 9), intubation (see Figure 6 and 9), advanced airway management techniques (see Figure 21 and 22), and chest compressions (see Figure 8, 11 through 13, and 20). There were tracheostomy
trainers, which had a hole cut in the neck to simulate an open stoma (see Figure 7 and 10). Some of the airway trainers also had adaptability for tracheostomy tubes (see Figure 5). The technologies were used to apply other respiratory therapies including oxygen, bronchoscopy, nebulized medication, humidification, mechanical ventilation, and physical assessment.

There was evidence of the mannequins being used to foster and develop critical thinking skills for the students. Much of this takes place during the third year of the program, when the students are on placement in the hospitals, as the director says; “We know not a lot of analysis or higher level critical thinking is really firmly engrained prior to getting into the clinical environment, so by the time they leave the clinical environment and have actually graduated … we achieve a lot at the level we expect ... from our students”. There was some evidence of this process beginning in first-year, as this statement from a discussion group shows; “So, you know simulation, although it is not real, it still gets the wheels moving ahead to start thinking analytically and digesting information and symptoms and stuff like that and trying to put them all together for treatment”. During observations of the faculty interacting with second-year students during labs, it was noted they would encourage critical prioritization, for example, when one student forgot to wash their hands during a scenario, the instructor asked the group “Is that a big thing or a small thing?” so its importance could be identified.
At Royal Columbian Hospital, I observed a faculty member setting up a simulated scenario. A low-fidelity torso was connected to a mechanical ventilator, through a tracheostomy tube placed into an artificial stoma in the mannequin. The instructor put a piece of tape over the end of the tube to simulate a tracheostomy tube clogged with mucus.

When the third-year student entered the room, she had to troubleshoot an emergency life-threatening scenario; she assessed the patient, attempted to pass a suction catheter down the airway, and then deflated the cuff around the tube while bag-mask ventilating the patient manually.

The atmosphere was filled with tension as the instructor created verbal urgency and indicated to the student what the patient’s oxygen level was.

The instructor asked questions towards the end of the scenario to guide the student and challenge her critical thinking ability, asking her; ‘is that a priority’ as she progressed through the patient care.

Vignette 4. Using simulation technology to develop critical thinking skills in life-threatening scenarios.

Critical thinking skills were encouraged during the first-year labs by having the students troubleshoot equipment. During the second-year labs, problem-based learning and case-based scenarios were introduced towards the end of the last semester, and emphasized just before the beginning of the third year of clinical placement. It is in the third year that this ability becomes most apparent, as this third-year student described; “I feel like you’d almost have an opportunity to draw all of the pieces together and kind of like mesh them up once you’re in clinical”.

Simulation technology was used in all three years of the program to introduce and work towards the development of critical thinking skills.

High-fidelity simulators were used for interdisciplinary team training within the third year of the program. At BC Children’s Hospital, this consisted of a portable simulator, moved from unit to unit to stage mock resuscitations. Third-year students also had an opportunity to participate in team training at CESEI, where physicians, fellows, residents, nurses, and RTs attended the simulated scenarios.
Soft skills – such as professionalism, organization, ethics, communication, and teamwork – were covered in a classroom setting and then assessed through general behaviour in the lab or hospitals over the course of the program. There were at least two faculty members who used simulation to teach these competencies. For example, the clinical faculty member at BC Children’s Hospital described a scenario where the role of the father of one of the patients was simulated. Students were then asked questions about the child’s care, and assessed for professional communication during the role-play. A professionalism self-evaluation and peer-evaluation adds to the feedback given to the student at the end of the year. The sleep assessment clinic where students do patient assessment on real or expert patients also contributes to development of professional communication skills in the second year of the program.

Simulation is used in all of the clinical evaluation exams for the program. This takes the form of lab exams within each year: The rubber arms, low-fidelity torsos, and intermediate-fidelity torso are used for skill assessment. The simulation equipment is set up to allow the student’s performance to be assessed as they go through their procedures and skills. The clinical faculty members indicated that for most skills, they do not require the students to demonstrate competency before working with real people. They are aware the students would have had to pass clinical lab exams at the end of the second year, one month prior to entering their clinical placements - and successful completion of these exams is evidence of a student who is ready to use the skills safely on patients.

Simulation technology was not specifically used for research within this academic environment, although one faculty member was using it for research while completing a masters degree program.

Advantages and Benefits
Advantages and benefits to using simulation technology within the RT training program were evident throughout the three years. Other than the obvious benefits (patient safety, ethics of training in simulation, etc) there were other advantages uncovered during the research.

During one observation session with first-year students, they were applying nebulizer masks to each other. The students were assessing air flow rates of the nebulized gases and were able to peer directly into the mask ports, holding their hands up to the sides, whereas with a real patient they would have been invading personal space and inducing claustrophobia by performing this act. Using simulated patients allowed them to get close enough to learn how the airflow patterns were moving. In another example, the first-year students talked about how learning how to do CPR on a mannequin gave them the tactile feedback necessary to learn appropriate force and depth; “even though it might not be a hundred percent bang-on similar to breaking ribs, when you’re actually doing it on someone”. The second-year students talked about how use of simulated patients allowed them to overcome fear of touching another person during physical assessments; “there’s so much stigma about physically touching somebody and like so many social rules that we’re trained to be nervous when we go and physically touch someone and we have to get over that”. Third-year students talked about how practicing pulmonary function tests in simulation before performing them on real patients increased their speed, which saved patients time when they came to the lab for their testing.

While discussing the advantages of simulation technology in the interviews and discussion groups, two themes stood out; improved confidence and improved competence.

The didactic faculty talked about the benefits of using simulated patients in that it allowed students to overcome the nervousness they invariably feel when having to assess or even just talk to real patients in the clinic or hospital setting. First-year students talked about how
applying therapy to another student helped them get used to having to ask someone’s permission to touch them; “touching someone’s face is kind of like an awkward and odd experience to go through the first time”. A second-year student explained how her confidence level increased even further when she worked with students in the class outside of her usual group – the patient seemed like a real stranger and this made her feel good about her skills. Second-year students also talked about how having self-confidence in their simulated skills allowed them to transfer that confidence to the clinical environment, and bringing that confidence into a patient’s room calmed them and allowed them to trust more in their clinician. One third-year student said she thought patients could probably tell when a student was nervous due to their body language, and practicing in simulation quelled those nerves and allowed them to project a confident attitude. A third-year student, in reference to arterial blood gas punctures, gave another example of why gaining confidence with simulation is important;

“You have an 83 year old in front of you who is terrified and you know her arms are like – you know she’s really tiny and you don’t realize how intimidating it is that you know that your skill set is not really great. But you don’t know how to convey comfort because you don’t have enough confidence to reassure her that you’re not going to miss [the arterial puncture]”.

The other primary advantage to using simulation for training according to the participants was improved competence. The program director felt strongly about use of simulation technology to improve competency; “without it, you can’t achieve what you need to achieve at the far end, which is competent graduates”. The third-year students talked about how their repetitive practice in simulation paid off by alleviating some of the stress that came with performing high-risk skills on real patients. This group of students also reiterated the importance
of gaining clinical competence through repetition in simulation as it applies to patient safety – in that without firm knowledge of skills, there could be serious adverse events.

Learning with simulation was not always a serious matter, as the title of this thesis indicates, and as this first-year student explains; “sometimes, it is fun to play with the dolls”. Other students also described some of the fun associated with working with human simulators. The second-year students were excited about learning through the simulation medium: They had nicknamed one of the torsos “pickle-face” (see Figure 7) and some of them seemed to relish the needle insertion into the rubber arm (see Figure 14). The third-year students also pointed out the arms as being fun to use, primarily because the procedures could be completed in entirety, and it closely simulated real practice. They also agreed that working with AirMan® (see Figure 21) was an enjoyable experience for them, although there were some who felt it had some physical characteristics that made performing skills more difficult than it would be in reality.

Disadvantages and Challenges

While watching the first- and second-year students work with simulated patients, I was impressed by the speed with which they switched in and out of their respective roles. One student would be acting as a patient, and would often step out of that role to remind the therapist they had missed a step in the procedure. The therapist would sometimes stop treating the other student as a patient and ask them a question about their lab manual. Either way, the role-play resumed immediately afterwards with a seamless transition. They made it look easy – but when I questioned the students about it, one of the first-year students said that it did disrupt learning to some degree;

“When you make a mistake, often you lose a bit of your confidence so when the student that’s working on you makes a mistake and you correct them, then it is kind of hard for
them to continue on in their authoritative role that they were taking, as, like, the professional, and you’re the patient”.

All of the fun could sometimes lead to cavalier behaviour. One of the didactic faculty noted how students who were not treating their simulated patients as real patients and laughing instead of treating the case seriously were at risk to do poorly on lab exams, as they missed some key components of a checklist such as asking for patient consent. Although I witnessed several humourous moments during the many hours of lab observations (in one instance, a student forgot to apply pressure after a simulated arterial puncture on a rubber arm, so he ran across the room to apply gauze, pretending blood was spurting out), I did not observe any unprofessional behaviour.

During the second-year student discussion, one person stated that simulation technology could be a distraction to learning. She referred specifically to a circumstance where they had been allowed to use the high-fidelity simulator in a first-year lab. This was not a lab where they had been assigned to work with the simulator, but the instructor had allowed them to try it out. She indicated the novelty of being able to play with the high-tech doll resulted in the students not getting much work done during that period.
Many of the participants reported technical difficulties with the simulation equipment. The rubber arms are used extensively for arterial puncture training in the second and third years of the program, so the skins wore out quickly. One student remarked how repeated punctures looked like “track marks” and made it obvious where the needle should be inserted, reducing the learning opportunity for anatomical land marking. Some of the high-fidelity mannequins were difficult to intubate, as this third-year student described; “learning the scope insertions was not reflective of a real patient…you were sort of struggling to make it work”. Access to the simulation technology was another difficulty encountered by students. Not all of the third-year students had an opportunity to work with the high-fidelity systems while on clinical placement, and TRU does not own most of the equipment used for simulation in the hospitals. With increasing enrollment, the program sometimes struggled with being able to provide enough technology to meet the needs of students in the first two years.

**Vignette 5.** Difficulty simulating a resuscitation with a low-fidelity torso in an office setting.

During my observation of a simulation scenario at Royal Columbian Hospital with a low-fidelity torso, I witnessed many difficulties during the 30-minute session. This took place in an office setting, and the student did not have all of the equipment available, therefore had to pantomime some steps such as pretending to don gloves. Without high-fidelity, the student needed to stop and ask the instructor what the vital signs were, and the instructor needed to periodically tell the student if the patient was breathing or not. At one point, the student attempted to pass a suction catheter through the tracheostomy tube inserted into the mannequin. Not sure whether the catheter wouldn’t pass because of the limitations of the accuracy of the rubber anatomy, or whether it was an intentional part of the simulation, the student had to pause the emergency resuscitation to ask the instructor if the suction catheter passed through the tube or not. The mannequin did not have simulated lungs, so the student was unable to determine if the ventilator was functioning appropriately. At the end of the scenario, the student reflected that she had forgotten to lay the patient supine during the scenario, but explained that it was difficult to remember to do this as the patient was a torso trainer and had no abdomen, arms or legs.
There were other discussed and observed disadvantages with the fidelity levels of the simulation equipment used in the program. The didactic faculty, for example, was using radial artery catheters for puncture repeatedly until they became too dull to push through the rubber skin. They had to remind the students that in a real hospital environment, these would be single-use only and never reused between patients. The blood gas syringes were likewise rinsed and reused. Some students were confused when they attempted a blood gas puncture on a rubber arm and got clear fluid instead of mock blood. This happened because water used to simulate Lidocaine had previously been injected under the skin to numb the area, and this had not been absorbed into the underlying tissue as it would have on a real person. The lung simulators were not able to adequately mimic a normal respiratory pattern, so the students were unable to see what real patient-ventilator interaction might look like until they began their clinical rotations. The faculty had to give verbal descriptions of what a patient reaction might be to the ventilator changes they were making.

One student expressed a strong dislike for working with the dolls, saying they “creeped me out” particularly the dolls that had missing arms. Other students said they were unprepared for the emotional, human side of working with patients after using nothing but inanimate unresponsive mannequins in lab; “I think the one thing that the way we learned excludes all of the time is the human response to what we’re doing”. They also said that use of simulated patients (other students) made it routine to have normal patient assessment parameters and they were not conditioned to finding abnormal values as they would with real patients in a hospital. Other students said that with the low-fidelity trainers, there is no consequence to errors or treatment, and therefore there is not always immediate feedback to correct their skills or technique, such as expressions of pain or bleeding. This was echoed by another student, who
said; “even if you’re putting the [oxygen] mask on the doll, he’s not going to say anything, he’s
not going to complain that you’re hurting him so it’s harder to be more gentle”.

Each participant, or group of participants, that was asked about challenges with using
simulation technology to learn indicated that resources were the largest barriers. Table 4
includes some of the specific comments made with regards to lack of funds and resources. The
code resources was generated 42 times within the analysis of the transcripts (see Appendix E),
and was a topic of much discussion by participants. These resources were listed primarily as
financial, but also included human resources such as faculty and student availability. Other
challenges mentioned less frequently were the complexity of implementing more simulation into
the curriculum, the length of time it might take to incorporate something new into the
curriculum, and faculty buy-in to support increased use of simulation in the program.

Table 4.

*Evidence of Resources as the Greatest Barrier to Use of Simulation Technology in the TRU RT Program.*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Resources identified as lacking</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program director</td>
<td>Financial</td>
<td>“There’s only so much capital that you’re typically able to secure”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I hear people teaching with high-fidelity simulation in environments similar to ours, and we’re so far away from having that as an even goal, let alone the actual resources to do that”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“We don’t have endless amounts of dollars to provide them with the experience that high-fidelity…could have”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“We have to be careful with our application of high-fidelity because it is a resource that will be – it is very expensive”.</td>
</tr>
<tr>
<td>Clinical faculty</td>
<td></td>
<td>“What if it all broke down, you know, you can pay this tuition and not do simulation, or you can pay more and use simulation, it would be better to pay more”.</td>
</tr>
<tr>
<td>Role</td>
<td>Resource</td>
<td>Quote</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clinical faculty</td>
<td>Time (student)</td>
<td>“We have such a limited time here at this site” referring to the time students spend on rotation at BC Children’s Hospital. “We’re at 80 now, depending on how things go we could be at 100 in the near future for students, so that challenge to be able to mobilize that many people through high-fidelity simulation will be challenging.”</td>
</tr>
<tr>
<td>Program director</td>
<td>Time (faculty)</td>
<td>“There’s a huge human resource impact”.</td>
</tr>
<tr>
<td>Clinical faculty</td>
<td>Didactic faculty</td>
<td>“Time is a limiting factor for health care providers that know how to run the simulator, unless one of those people are on site, the simulator just sits there”. “There’s just me, and there’s eighty students, right, so how can one person go to that level, right, with that many people” referring to teaching effectively with high-fidelity simulation. “You’d have to have at least one full time faculty member doing nothing else”. “It’s the staffing, right, that’s what’s really going to be expensive”. “We’d love to do more of it, it’s just the time and the other barriers that are in the way right now”.</td>
</tr>
<tr>
<td>Program director</td>
<td>Equipment</td>
<td>“If you don’t have enough of any one piece of equipment you can’t get equal access and enough access for each student, then you can’t really use that tool”.</td>
</tr>
<tr>
<td>Program director</td>
<td>Space</td>
<td>“The biggest problem would be physical space”.</td>
</tr>
<tr>
<td>Didactic faculty</td>
<td></td>
<td>“It’s more the high-end stuff, we just don’t have the equipment. So we’re trying to find out where to do this and have the space to do this”. “How much it was going to cost to renovate, costs were extraordinary”. “I see what we do need is a special dedicated simulation room as we move to the higher fidelity to create that environment that’s reminiscent of clinical”. “Limitations are probably space and, as I’m sure you can appreciate, the dedicated resource of running a full simulation lab”.</td>
</tr>
</tbody>
</table>
Limitations

There are some limitations to the quantity and reliability of data collected for this study. The cataloguing of low-, intermediate-, and high-fidelity equipment is comprehensive in covering the first two years of the program and for the neonatal clinical site placement at BC Children’s Hospital in third-year. In regards to the adult hospital placements, I visited only one site and faculty from others (Royal Inland Hospital, St Paul’s Hospital, Vancouver General Hospital, and Victoria General Hospital) were not contacted for this study. Although I think it is reasonable to assume a similar catalogue of equipment exists for use at the other clinical placement sites (and the didactic faculty confirmed this when questioned), there may be some simulation equipment available for use by students at those hospitals that the program faculty was not aware of. The selection of one adult site to be representative of all five may have underestimated the number or type of technology that is in use in the third year.

My observations of the students using simulation equipment or simulated patients in the lab setting may have been affected by my presence. Although steps were taken to ensure I was non-disruptive (prior to the lab, the faculty briefed the students by telling them I was not there to answer questions about how to do procedures or respiratory therapy in general) and I had introduced myself and the described the purpose of the research, the students may have been intimidated by my job title (Professional Practice Leader for Respiratory Therapy at Vancouver General Hospital). I suspect this may have been the case, as I noted the students became more serious about their work whenever I came near in the lab.

I was unable to observe students using high-fidelity simulation during the course of this research. The faculty had not yet implemented this form of simulation in the second year of the program, and the third-year students were using it inconsistently, infrequently, only at a single
hospital site, and outside of my data collection window for this study. It is possible, therefore, and even likely based on the evidence from the literature review that there are other theories supporting the team training scenarios with high-fidelity simulators. Engeström's (2001) activity theory or Bandura's (1977) social theory may have been applicable to the interdisciplinary teams using high-fidelity simulation within the hospital sites, and perhaps even during the last semester of the second year of the TRU program, when the intermediate-fidelity airway trainer torso is used by groups of RT students.

Palys and Atchison (2008) challenge the common practice of depersonalizing research and instead encourage researchers to maintain transparency in their personal interest (p. 143). My experience as an alumna of this program (in 1995), followed by work as an RT precepting third-year students, as well as roles as Staff Educator and Professional Practice Leader have given me insight and layers of context in interpreting meaning from this research. The challenge has been to maintain neutrality during factual reporting of the data, and to use my personal experiences only to add context to my interferences drawn from the results of the study.
Discussion

TRU has historically primarily used low-fidelity simulation to train therapists. Their contingent of this technology is extensive and diverse. In using a mix of low-fidelity technology and simulated patients, the faculty create a safe medium through which high-risk skills and respiratory procedures can be learned and evaluated. Most of this basic procedural learning occurs during the second year of the program. High-fidelity simulators are used seldom and inconsistently, at a small number of the clinical placement sites. In these cases, the equipment is used to train staff teams and the student respiratory therapist takes part as a member of that team. In considering the various technologies through which therapists are learning within the program, there are unique advantages and disadvantages to each. These are incorporated into the discussions and recommendations below.

In reviewing and reflecting on the results, comparing with the known information from the literature, and with consideration to the limitations in this study, four distinct inferences can be made.

1. Deliberate practice is the predominant learning theory used with simulation technology for the acquisition of skills and procedures in the TRU RT training program.

   The data in this study so overwhelmingly pointed towards deliberate practice as the predominant andragogy within the first and second year of the program, that it seems unlikely there are any other theoretical frameworks that could be ascribed to the learning with low- and intermediate-fidelity systems. Triangulation with at least six points of view (see Table 1) supports this conclusion. Each theoretical component is supported by at least four sources. Deliberate practice theory was the most often used code (N = 73) during data analysis. The interview and observation guides (see samples, Appendix C and Appendix D) were specifically
structured to gather information on any theoretical frameworks used for didactic or practical instruction within this program. Although other learning theories were mentioned by some of the faculty as used within the overall curriculum (e.g. Gagne’s theory of instruction), none were put forward as specific to teaching with simulation.

During the data analysis, in addition to specific andragogy, I was additionally searching for epistemologies that may supplement or provide alternative explanations for the evidence collected. With the strength of evidence in feedback (in the form of debriefing) both observed and reported as being provided consistently to the students who were learning with simulation, the concept of behaviorism as a theoretical model for facilitating learning was considered. The behavioural model described by MacKeracher (2008, p. 212) is a simple stimulus-response approach to learning. This was an easy assumption when watching the students perform the same skill repeatedly, with some reinforcement provided by the instructors leading to a desired adaptation. However, it became evident that behaviourism does not apply when the students were then asked to describe what the patient response might be to the therapy, or how they might adapt their behaviour when medical complications occur. The medical practitioner must be required to think critically and respond appropriately to an incredibly complex human patient system, and this does not support behaviourism as a predominant epistemology, although it may have some application when the procedural steps are first acquired.

It is much more likely that cognitivism applies to the learning that occurs with simulation technology, as students are required to use information processes including inference, reason, pattern recognition, analysis, memory and association as they gain skills and adapt them within new environments in the hospital sites. One of the theories posited by (MacKeracher, 2008) as useful in facilitation of physical learning is cognitive apprenticeship, including phases of
“modeling, coaching or scaffolding, fading, solo performance, and reflection and discussion” (p. 147). Within the theoretical components of the deliberate practice model, the expert guidance provided by the didactic and clinical faculty consisted of all of these techniques to facilitate learning.

In my discussion with the third-year students who had had an opportunity to participate in team training with the high-fidelity simulator, there was evidence of constructivism as students described how they were able to take their cognitive skills and real patient experiences into a collaborative, interdisciplinary environment for meaning-making and problem-solving. I was not able to have an opportunity to observe high-fidelity simulation in relation to this program, and this is not a consistent experience used for education during the third-year placements. Some students were able to work in simulation with a team from BC Children’s Hospital, but this learning opportunity was not regularly scheduled as part of the curriculum for learning. The TRU program had purchased a refurbished high-fidelity simulator for use with second-year students, and was expecting to incorporate this into one of the didactic course labs in 2011.

After completion of the second year of the program, the students have approximately a month off before starting their third-year clinical placements. They begin their site placement with an orientation to the area, and are partnered with experienced staff therapists on shift. The students begin performing skills and procedures on patients, under the watchful eye of their preceptor, and gradually take more responsibilities for patient care. By the end of their 10-month clinical placement rotations, they are working independently as therapists. The mandate of this research was to assess learning with simulation technologies, and therefore I did not focus on learning theory in relation to working with real patients. However, I would speculate that models of situated cognition where the learner gains knowledge within context when fully
immersed in a hospital are effective frameworks to describe the student’s transition to learning on clinical placement. W. Jacobson (1996) provides this description; “situated cognition provides a way of thinking and talking about learning culture that is consistent with the nature of culture and the experience of learning” (p. 13). This would be key when the students are placed within the cultural complexity of the hospital settings.

The theory of deliberate practice is well established in the literature as useful for healthcare training with simulation technology. This RT training program incorporates all aspects of the framework as defined by Ericsson (2004, 2008) and expanded by Kneebone (2005) to include aspects of repetitive practice, expert tutelage, and transfer to practice in a supportive learner-centered environment. Although the faculty did not articulate this theory as the motivation for setting the stages of the curriculum and may not be specifically aware of its components, the program seems to have evolved into a structure where learning follows this conceptual framework with excellent results, producing high-quality, practice-ready graduates.

2. Low-fidelity simulation can be enhanced with psychological fidelity techniques for cost-effective training in high-risk skills and procedures.

In a program free of financial constraints, an ideal training program might consist of a state-of-the-art high-fidelity simulation lab in a perfectly recreated hospital environment, with full-body mannequins ready and available for any procedure, actors playing interdisciplinary roles, staffed by a round-the-clock contingent of trained faculty. In reality, this program does not have those resources available, although they are investigating the first stages of developing a dedicated multidisciplinary health simulation lab on the university campus in the future. The low-fidelity part task trainers, torsos and mannequins may be old and somewhat dated in comparison with the latest innovations in simulation technology, but this equipment continues to
be used extensively within this program as it meets its purposes in providing a medium for repetitive practice in skills and procedures.

Levels of realism were a popular topic during the discussion groups and interviews. Most of the simulation used in the program is low-fidelity, resulting in creative use of physical, semantical, and phenomenal ways of thinking during instruction. The physical elements of the simulation equipment varied widely from real humans (use of simulated or expert patients), to plastic dolls, to “Cabbage Patch Kids®” – a popular children’s plush toy (see Figure 10). Observations showed the students would use whatever was nearby to help them learn. For example, when attempting to find anatomical landmarks on the rubber arm for an arterial blood gas puncture, the students would turn from the simulated arm to their lab partner’s arm to check the location of a real pulse, and then back to the simulated arm for the needle poke.

The students also seemed experienced in quickly incorporating changes in semantics during a scenario; for example, an instructor would give a minute-by-minute verbal update of changing physiology as treatment progressed. Students rolled their eyes a little when talking about the clunky old master-slave lung system (see Figure 19), a series of bellows and springs held together with elastic bands and connected to an old mechanical ventilator, which was meant to simulate a spontaneously breathing patient, but the system performed its basic function. They turned to their lab instructor for a verbal description when they needed to know what a variable or realistic patient-ventilator breathing pattern might look like.

Students were also adept at incorporating phenomenal relevance in situations; they seemed instinctively able and willing to believe the scenario was real, and acted accordingly, despite the obvious limitations in physical and semantical realism. During the second year of the program, the students had to create this phenomenal realism for themselves in a lab setting,
which many of them did by role-playing as they worked with simulation technology and simulated patients. Dieckmann et al. (2007) explains the relative importance of Uwe Laucken’s three modes of thinking; “In many cases, it is more cost effective to establish strong semantical and phenomenal frameworks of the scenario that help participants interpret information and enact their roles, rather than merely trying to maximize the physical fidelity”. The students seemed cognizant of the full weight of responsibility of being required to perform high-risk procedures as they entered the clinical environment, and wanted to do everything they could to maximize their competency and confidence before entering the clinical site placements.

The students, on several occasions, suggested ways to improve and enhance the fidelity of the existing resources with cost-effective means. This included the verbal enhancement of psychological fidelity by creating a sense of urgency during simulated scenarios, maintaining the fidelity of the equipment by frequently replacing the skins of the arms to avoid tell-tale previous puncture marks, and bringing some realistic patient responses into the training such as expressions of discomfort and pain during procedures. Within my work experience as a RT preceptor at Vancouver General Hospital, I have seen students lose confidence or be unsuccessful in performing high-risk skills, as they are nervous or unprepared for real human responses to the therapies they are providing. For example, one student dropped the needle the first time a patient jerked his arm away during an arterial blood gas puncture, another student stopped providing CPR when he heard a rib break, and another let go of an unsecured artificial airway when a patient began to cough. Entering an acute hospital environment for the first time can be shocking, and preparing students for transfer from a simulated setting to a real one using psychological fidelity, particularly in semantic and phenomenal aspects, is an inexpensive way to ease this transition and add to their confidence.
3. High-fidelity simulation may have an advantage over low-fidelity simulation for development of critical thinking analysis and problem-solving skills.

RT students in the TRU program have traditionally learned critical thinking skills within a real clinical environment. As a student progresses through their hospital rotations, they assimilate their procedural skills with an ability to see the patient as a whole and interact with a team to solve complex problems. This transition from low-fidelity simulation training directly to the preceptor-apprentice model could result in unacceptable levels of patient risk, as preceptors are not always aware of a student’s intended behaviour and rationalization before they begin patient interventions. Although preceptors are usually nearby to provide supervision, mistakes are possible and in RT practice, could easily lead to patient morbidity or mortality. For example, misadjusting ventilator tidal volume could result in a pneumothorax, too-rapid manual ventilation could result in cerebral ischemia in head-injured patients, and overinflating an endobronchial tube cuff could result in a ruptured bronchus. Many of these skills can be simulated with low-fidelity and although this may decrease the incidence of error, it does not train students to deal with its consequence.

During the analysis of these results, it became evident that learning skills and competencies with low-fidelity systems can result in competence for skill acquisition. However, using low-fidelity simulation equipment created challenges and distractions for students who were attempting to perform in a more complex but inauthentic scenario (see Vignette 5) to manage a simulated patient with a life-threatening complication. There were frequent interruptions required to check semantics, physical limitations to the equipment so that many of the procedural interventions couldn’t be carried out, and learning was disrupted on several occasions while the student was briefed on steps that were assumed but couldn’t be simulated.
Augmenting the semantical and phenomenal aspects of a scenario to compensate for the low physical fidelity seemed to work well for learning individual procedures, but these techniques did not seem to be adequate in training students to think critically without disruption while managing a complex patient scenario.

In the health care environment (as in all occupations), human error is inevitable. Students must not only be trained to reduce the incidence of errors, but to know how to recognize them and respond appropriately when they occur. Practicing the skills in low-fidelity simulation does not demonstrate the resulting physiologic patient consequence to error. The student therefore may not recognize these complications if they occur or be able to respond immediately to correct the resulting scenario, leading to injury or death. High-fidelity simulation with effective debriefing can allow for the instructor to explore the student’s cognitive thought processes, assumptions, and knowledge in a way that is not always possible in the clinical environment (Bond et al., 2008, p. 1040).

High-fidelity simulation provides the ideal safe learning environment to recognize a “near-miss” and learn the required corrective actions. This enables students to learn from error, not be penalized for it – and is an ethical choice for patient safety. Nourishing a culture of allowable error in simulated learning environments may also help to “break the culture of silence and denial in medicine regarding untoward outcomes and mistakes and their implications about the learner’s competence” (Ziv et al., 2003, p. 785). People who consent to treatment at a teaching hospital recognize it is a learning institution, but they have a right to expect safe, quality care from all caregivers. Students, in turn, have a right to ensure they can practice and learn in a safe and responsible environment.

High-fidelity simulation would additionally be the most appropriate choice in developing
problem-solving strategies for low-frequency events that they may not encounter during the course of their clinical placement. Many therapists in BC are hired directly into acute care environments where they practice with little supervision or direction. As specialists in ventilation, these therapists will encounter relatively rare pulmonary disorders that require unique care strategies (e.g. status asthmaticus, bronchopleural fistulas, Adult Respiratory Distress Syndrome). Caring for patients with these conditions does not just involve adept skills; the critical thinking and analysis process is essential. Exposing the student to these scenarios and practicing treatment strategies with high-fidelity simulators in environments that mimic clinical practice will help to provide a consistent learning experience to each student, strengthening the availability of well-rounded and competent graduates for healthcare organizations.

The current training model uses low-fidelity simulation for skills training, followed by the preceptor-apprentice model within a real clinical environment for development of critical thinking skills and problem analysis. High-fidelity simulation offers a safe and ethical learning alternative to this model, providing a learning medium for further development of cognitive strategies, preparation for caring for the consequences of error, and providing consistency for learning responses to low-frequency events.

4. Optimal placement of high-fidelity simulation within the TRU RT curriculum would be in the transition to and during student placement in the clinical practice environments.

High-fidelity simulators require extensive resources to support use, and careful consideration should be made to choose an optimal placement within the curriculum in order to provide the greatest benefit. During the first year of the program, the students primarily learn equipment and basic skills, and during this time, a high-fidelity simulator with all of its bells and whistles may be more of a hindrance than an enhancement to learning, as these students
described during the discussions. Most of the second year of the curriculum is focused on repetitive skills practice to learn and perfect techniques, and reinforce theory. Low-fidelity simulators meet this need adequately; although there is room for improvement, as described in point number two above. Towards the end of the second year and during the clinical placements, the students need to move beyond skills and procedures and begin to develop an ability to think critically and function as part of an interdisciplinary team, and this is where high-fidelity simulation can have the biggest impact.

The use of high-fidelity simulation for education at the hospital sites optimizes the ability of the TRU program to provide realistic team training. Patient care involves complex interactions between members of many health disciplines, including physicians, nurses, physiotherapists, dieticians, occupational therapists, speech-language pathologists, pharmacists, and others. Training in simulation provides occasion for facilitating teamwork, improving communication, and dedicates time for learning through debriefing and reflection. It would be challenging for any university setting to provide an opportunity for bedside interactions between students of all of these disciplines, and even if they could, without expert facilitation from experienced caregivers, a group of students interacting only with each other may not be able to simulate realistic scenarios.

Of further benefit to the TRU program is the ability to share resources with the hospital sites. Financial resources was the greatest barrier to incorporating high-fidelity into the curriculum, as the technology itself is prohibitively expensive (upwards of $100,000) and requires at least one trained facilitator to run the software. With public health care facilities operating under stretched budgets and students responding negatively to tuition increases (see Table 4), a joint partnership between hospitals and academic training institutions makes sense for
both parties. Students get the benefit of learning alongside experienced caregivers in team training scenarios, and hospitals get the benefit of developing confident, competent, safe, and practice-ready graduates to add to their workforce.

**Recommendations**

Based on the findings from this study and supported by the evidence in the literature, use of deliberate practice as the predominant learning theory should continue to guide and inform educational choices for respiratory therapists in this program. Use of low-fidelity simulation equipment is optimized as a cost-effective way to train therapists, but there is room for improvement specifically in the enhancement of this technology through environmental and psychological means. The addition of further high-fidelity simulation technologies may enhance the development of critical thinking and problem-solving skills, and the best choice for curriculum placement for high-fidelity equipment would be at the end of the second year or incorporated into the clinical placement of the training.

Results from this study are useful in providing a rationale for, and guiding choices in, simulation technology for all new and existing RT training programs across Canada. Detailed and descriptive data supported by a strong theoretical framework provides rich information for health educators to use when determining use of simulation technology for training in this profession. The qualitative methodology used focuses specifically on a single case and therefore evidence cannot be directly extrapolated as applicable to other professional training schools or academic institutions, although a comparison case would be an interesting lens for examination of a similar program. Other recommendations for future areas of study include further investigation into the theoretical frameworks supporting RTs learning with high-fidelity simulators in team training environments. While much literature exists for physician and nursing
professions, the specialized practice of RTs learning as an allied health team member with simulation technology is unclear.
Summary

This case study delivers a clear and comprehensive description of the simulation technology in use throughout all three years of the TRU RT program, and describes how the equipment is used for education and evaluation for learners. In addition, this study reports on advantages, disadvantages, challenges and benefits for using these technologies, as well as contributing to the rationale for use in an RT training program performing high-risk activities. It provides clear evidence for predominant use of deliberate practice as the theoretical framework used for learning with simulation in the program.

The success of the exemplary program at TRU offers some evidence that use of low-fidelity simulation for skills training is an effective means of procedural training, but the inferences drawn from this research offer insight as to the benefit that could be gained through enhanced attention to psychological fidelity. The recommendations include incorporating high-fidelity simulators to provide a safe and ethical means of team training and development of critical thinking skills, strategically placed in the transition to and during the third-year clinical placement at hospital sites. Sharing costs with hospitals offers a reasonable solution to the greatest barrier of the provision of financial support for this technology.

“Playing with dolls” is an effective and necessary learning strategy in the Thompson Rivers University RT training program, and this study provides a compelling description of current use and suggestions for improvement strategies in the future.
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## Appendix A

### Glossary of medical terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal thrusts</td>
<td>A procedure to apply rapid firm pressure to the abdominal cavity to produce a manual cough</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>Abnormal lung sounds heard when listening through a stethoscope</td>
</tr>
<tr>
<td>Aerosolization</td>
<td>A fine mist or spray of tiny particles, used to deliver inhaled moisture or medications to the airways</td>
</tr>
<tr>
<td>Alveolar-capillary diffusion</td>
<td>Diffusion of oxygen and carbon dioxide between the air in the lungs and the blood in the pulmonary circulation</td>
</tr>
<tr>
<td>ARDS</td>
<td>Adult Respiratory Distress Syndrome – multiple etiologies leading to severe pulmonary dysfunction and multi-organ system failure with a high mortality rate, requiring intensive care and specialty ventilation</td>
</tr>
<tr>
<td>Arterial blood gas cannulation</td>
<td>A procedure to insert a catheter into an artery to provide a conduit to monitor pressure or take arterial blood samples</td>
</tr>
<tr>
<td>Arterial blood gas puncture</td>
<td>A procedure to insert a needle into an artery to take an arterial blood sample</td>
</tr>
<tr>
<td>Auscultation</td>
<td>Listening through a stethoscope to hear heart, lung or bowel sounds</td>
</tr>
<tr>
<td>Bag-mask manual ventilation</td>
<td>Procedure of using a mask to cover mouth and nose and squeezing a bag to force air into the lungs during pulmonary arrest or dysfunction</td>
</tr>
<tr>
<td>Blood gas</td>
<td>Dissolved gases in the blood (i.e. carbon dioxide, nitrogen and oxygen)</td>
</tr>
<tr>
<td>Bronchoalveolar</td>
<td>Pertaining to the bronchi of the lungs and the alveolar air sacs where gas exchange takes place</td>
</tr>
<tr>
<td>Bronchopleural fistula</td>
<td>An unnatural connection or hole between the lung tissue and the pleura (dual membranes covering the lungs)</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>A procedure to insert a flexible scope into the lungs to remove secretions, inspect anatomy or take biopsies</td>
</tr>
<tr>
<td>Central line</td>
<td>A catheter inserted into a large central vein to monitor pressure or take venous blood samples</td>
</tr>
<tr>
<td>Cerebral ischemia</td>
<td>Brain tissue that receives inadequate levels of oxygenated blood</td>
</tr>
<tr>
<td>Chest compressions</td>
<td>A procedure to squeeze the heart between sternum and spine to create blood flow during cardiac arrest</td>
</tr>
<tr>
<td>Code blue</td>
<td>Terminology generally used to describe a cardiac or pulmonary arrest situation in a hospital or pre-hospital setting</td>
</tr>
<tr>
<td>Cricothyroidotomy</td>
<td>Creation of a hole in the membrane of the trachea to facilitate breathing</td>
</tr>
<tr>
<td>Deadspace</td>
<td>Air that moves through the lungs without delivery oxygen to or offloading carbon dioxide from the pulmonary circulation</td>
</tr>
<tr>
<td>Defibrillation</td>
<td>Application of an electrical charge to the heart to change the rhythm</td>
</tr>
<tr>
<td>Endobronchial tube</td>
<td>A plastic tube reaching down into the bronchus of one lung</td>
</tr>
<tr>
<td>Intubation</td>
<td>A procedure to insert a plastic tube into the trachea to aid respiration or facilitate mechanical ventilation</td>
</tr>
<tr>
<td>Laryngospasm</td>
<td>Spasm of the vocal cords</td>
</tr>
<tr>
<td>Lung compliance</td>
<td>A measurement of the stiffness of the lungs and chest wall</td>
</tr>
</tbody>
</table>
| Lung resistance                           | A measurement of the resistance to flow through the airways of the
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>lungs</td>
<td>A machine connected to a patient with an artificial airway and used to inflate the lungs to aid in respiration</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>Pertaining to the newborn period of life</td>
</tr>
<tr>
<td>Neonatal</td>
<td>Abnormal air between the pleura (dual membranes covering the lungs)</td>
</tr>
<tr>
<td>Oxygen saturation</td>
<td>A measure or calculation of the amount of hemoglobin in red blood cells that is bound to oxygen molecules</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>Testing procedures for lung function</td>
</tr>
<tr>
<td>Pulmonary function</td>
<td>Blood that moves through the pulmonary circulation without picking up oxygen or offloading carbon dioxide</td>
</tr>
<tr>
<td>Pupillary reaction</td>
<td>A test of the constriction of the eye’s pupil to light</td>
</tr>
<tr>
<td>Radial pulse</td>
<td>A life-threatening condition of severe constriction and inflammation of the airways in the lungs due to asthma, usually requiring intensive care and mechanical ventilation</td>
</tr>
<tr>
<td>Stoma</td>
<td>Unnatural hole created in the body</td>
</tr>
<tr>
<td>Thoracentesis</td>
<td>Puncture through the chest wall to drain air or fluid from the pleura (dual membranes covering the lungs)</td>
</tr>
<tr>
<td>Tracheal suctioning</td>
<td>The process of inserting a catheter into the trachea to remove mucous</td>
</tr>
<tr>
<td>Tracheo-bronchial tree</td>
<td>The branching of the airways of the lungs from the trachea to the lower bronchioles</td>
</tr>
<tr>
<td>Tracheostoma</td>
<td>A surgical hole created in the neck through which a plastic artificial airway is inserted to aid in respiration, facilitate removal of secretions or facilitate mechanical ventilation</td>
</tr>
<tr>
<td>Tracheostomy tube</td>
<td>An plastic artificial airway tube placed through a hole (stoma) in the neck to aid in breathing, mechanical ventilation, or to facilitate clearing of secretions</td>
</tr>
<tr>
<td>Transtracheal ventilation</td>
<td>Emergency ventilation through a needle or tube through the neck</td>
</tr>
</tbody>
</table>
Appendix B

Sample participant information and consent form

**Researcher:**

Shari McKeown, RRT  
MA Graduate student, Royal Roads University  
Practice Leader, Respiratory Therapy, VCH-Vancouver

**Principal Investigator (Royal Columbian Hospital site):**

Stephen Blackie MD FRCP(C)  
Respiratory Medicine  
Royal Columbian Hospital  
Fraser Health Authority

**Principal Investigator (BC Children’s Hospital site):**

Alexander (Sandy) Pitfield MD FRCP(C)  
Clinical Assistant Professor, UBC Faculty of Medicine/Dept of Pediatrics  
Physician, Critical Care Division, BC Children’s Hospital  
Provincial Health Services Authority

**Research Supervisor:**

Susan Chandler, MSc., EdD.  
Chair, Distributed Education, Camosun College, BC  
Camosun College

**Royal Roads University Program Head:**

Judith Blanchette, Ph.D  
MA in Learning & Technology Program  
Royal Roads University
INTRODUCTION

You are being invited to take part in a research study to gain insight into the use of simulation technology in the RT program at TRU. This study is being conducted as part of a thesis to satisfy program requirements for a Masters of Arts program in Learning and Technology at Royal Roads University.

YOUR PARTICIPATION IS VOLUNTARY

Your participation is entirely voluntary, so it is up to you to decide whether or not to take part in this study. Before you decide, it is important for you to understand what the research involves. This consent form will tell you about the study, why the research is being done, what will happen to you during the study and the possible benefits and risks.

If you wish to participate, you will be asked to sign this form. If you do decide to take part in this study, you are still free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, you do not have to provide any reason for your decision not to participate and there will be no consequence.

Please take time to read the following information carefully before you decide.

BACKGROUND

Respiratory therapy is an allied health care profession where new graduates work within acute care environments performing high-risk therapies and treatments on patients. Simulation technology, which can range from a simple test lung to an advanced human patient simulator, allows students to practice high-risk procedures in a low risk setting.

PURPOSE

The purpose of this case study research is to explore and describe the use of simulation technology within the respiratory therapy (RT) program at Thompson Rivers University (TRU).

PARTICIPANT COMMITMENT

This study will consist of interviews with key members of the TRU RT program, photographs of the simulation technology in use, observations with groups of students in each year of the program, followed by discussion group sessions with the students. Interviews and discussion groups will be audio taped if participants consent. Notes will be taken during observation sessions with the students.
Your participation in this study would be in the form of an observation period while you use simulation technology in the normal course of your learning, followed by a discussion group session with other students facilitated by the researcher. The observation period will take place in a TRU lab setting. The discussion group will be approximately 60 minutes duration, at a date and time that is mutually convenient, at TRU in a classroom setting. The discussion group questions will focus on your experiences and ideas about simulation technology for learning.

POTENTIAL RISKS

Your name will not be used in any publication, but the student groups will be identified by program year and in the case of the third year students, by clinical placement site. There is a remote chance someone may identify you based on this data used in conjunction with observations and discussion group reports.

POTENTIAL BENEFITS

This study may expose you to some aspects of your professional development path you may not have previously considered, namely research or graduate studies. You will have an opportunity to observe some qualitative research methodology, which may provide benefit in your future professional career as a health clinician.

This research will allow the researcher to complete the course requirements for a Masters of Arts in Learning and Technology program at Royal Roads University. Knowledge gained about use of simulation technology in the TRU RT program will also be useful in the researcher’s position as practice leader for respiratory therapists in Vancouver area hospitals, to build on and continue use of this technology in ongoing professional staff development.

Publications resulting from this research will inform the respiratory therapy education community about simulation use for education and evaluation.

WITHDRAWAL FROM STUDY

Your participation in this study is entirely voluntary and the decision to participate or not will have no effect on your marks or opportunities for potential employment.

During the observation period, the researcher will be taking detailed field notes. The purpose of these field notes is to record observations about the use of simulation technology. This information will not be used to record or evaluate your performance with the skills or procedures in any way. During the discussion group, an audio recording will be made for transcription and analysis. The researcher will attempt to extract any observational notes or audio contributions from the data transcripts if you withdraw your consent during the study; however, this may be difficult to isolate and it is likely some of the data will remain.

CONFIDENTIALITY
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records identifying you may be inspected in the presence of the Investigator by representatives of Health Canada and the UBC Research Ethics Boards for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices.

Your participation will not be anonymous, as the interview will take place in person. You will be assigned a unique study number as a participant in this study. Only this number will be used on any research-related information collected about you during the course of this study. Your words may be cited within the publications and will be attributed only to ‘Student 1.1, Student 1.2’ etc. No personal identifiers will be published.

The list that matches your name to the unique identifier that is used on your research-related information will not be released without your knowledge and consent unless required by law or regulation. All data will be stored on a password-protected computer. The researcher will be the only person to have access to the raw data audio recording or notes. All data will be kept for a period of five years and then destroyed.

RIGHTS AND COMPENSATION

By signing this form, you do not give up any of your legal rights and you do not release the study investigator or other participating institutions from their legal and professional duties. There will be no costs to you for participation in this study. You will not be paid for participating.

CONTACT FOR INFORMATION ABOUT THE STUDY

If you have any questions or desire further information about this part of the study before or during participation, you can contact the researcher, the research supervisor, the program head or the principal investigators using the contact information at the top of this form.

CONTACT FOR CONCERNS ABOUT THE RIGHTS OF RESEARCH PARTICIPANTS

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact either Dr. Marc Foulkes or Dr. Allan Belzberg, Research Ethics Board co-Chairs. You may discuss these rights with one of the co-chairmen of the Fraser Health Research Ethics Board.

You may also telephone the Research Subject Information Line in the UBC Office of Research Services.
• I have read and understood the participant information and consent form and am consenting to participate in the study *Simulation Technology Use in the Thompson Rivers University Respiratory Therapy Program – A Case Study*.
• I have had sufficient time to consider the information provided and to ask for advice if necessary.
• I have had the opportunity to ask questions and have had satisfactory responses to my questions.
• I understand that all of the information collected will be kept confidential and that the result will only be used for scientific objectives.
• I understand that my participation in this study is voluntary and that I am completely free to refuse to participate or to withdraw from this study at any time
• I understand that I am not waiving any of my legal rights as a result of signing this consent form.
• I understand that there is no guarantee that this study will provide any benefits to me
• I have read this form and I freely consent to participate in this study.
• I have been told that I will receive a dated and signed copy of this form.

SIGNATURES

Printed name of participant ___________________________ Signature ___________________________ Date ______

I consent to an audio recording of the discussion group session  
(Signature) ___________________________

Email address of participant (used only to send you copies of publication(s)) ___________________________

Printed name of witness ___________________________ Signature ___________________________ Date ______

Printed name of researcher ___________________________ Signature ___________________________ Date ______
Appendix C

Sample interview guide

Participant: Faculty members, Respiratory Therapy (RT), Thompson Rivers University (TRU)

<table>
<thead>
<tr>
<th>Key Concepts</th>
<th>Questions</th>
<th>Interviewer resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I’d like to start by reviewing the research consent form with you.</td>
<td>1. Right to withdraw at any time, up to the point where transcripts are approved.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Session will be audiotaped.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Participant will be identified by title and work location (may cause loss of confidentiality).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Participant will be able to review transcript prior to data analysis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Questions?</td>
</tr>
</tbody>
</table>

| Demographics | For how many years have you been with the RT training program at TRU?                      |                                                                                       |
|              | For how many years have you worked in the capacity of a faculty member for the program?   |                                                                                       |
|              | Can you describe the courses you teach in this program?                                   |                                                                                       |
|              | Have you had specific training or instruction in teaching with simulation technology?      |                                                                                       |
I’d like to know what kind of simulation technology is currently available for use within the courses you teach (for first and second year students). Do you have:

A. Part task trainers? Designed to replicate part of the environment, often resemble part of the body, such as a test lung or rubber arm

B. Computer based systems? Used to model aspects of human physiology or pharmacology, simulated tasks or environments and allow interaction with these through a computer interface.

C. Virtual reality systems? Presents virtual objects or environments to all human senses in a way which tries to be identical to their natural counterpart.

D. Virtual reality with Haptic (touch sensitive) systems? Touch feedback used to produce a feeling of resistance when using instruments within the simulated environment
E. Human patient simulators?

E. i) Low fidelity? Full body or torso of a mannequin

E. ii) Intermediate fidelity? Instructor driven with less complex computer systems with some physiological signals, which the instructor adjusts to reflect patient responses

E. iii) High fidelity? Lifelike mannequin with physiological and respiratory responses to drugs and interventions, usually on a clinical monitor, incorporating speakers for verbal interaction, pulse, breath and heart sounds, papillary reactions and urine output.

F. Real patients or actors?

G. Simulated environments? Recreation of the clinical environment (i.e. hospital ward or ICU room)

<table>
<thead>
<tr>
<th>Reason for selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which simulation technologies have been purchased specifically for use in the courses you teach?</td>
</tr>
<tr>
<td>Were you involved in the decision? If so, how?</td>
</tr>
<tr>
<td>(if involved in decision making) What guided your selections?</td>
</tr>
<tr>
<td>(if involved in decision making) Did pedagogical theory help to inform your choices? If so, how?</td>
</tr>
<tr>
<td>(if involved in decision-making) Did the literature inform your decision? Could you describe how?</td>
</tr>
</tbody>
</table>
Use of simulation technology

Simulation technology can be used for various purposes in education programs, such as (list).

What are the purposes of simulation technology in the courses you teach?

*If clinical rehearsal or research, expand further.

Can you describe how simulation is integrated into the curriculum for your courses?

How is simulation used in your courses with reference to pedagogical theory?

List:

- **Education** (conceptual knowledge, basic skills including rationale and decision making)
- **Training** (tasks)
- **Performance assessment** (competency evaluation, exams)
- **Clinical rehearsal** (prior to undertaking a difficult patient procedure in clinical environment)
- **Research**

Do students have objectives to meet using simulation?

Is performance individualized, or are all students required to meet the same standards in simulation?

e.g. deliberate practice, social theory, activity theory, behaviourism, cognitivism, constructivism, scaffolding
<table>
<thead>
<tr>
<th>How is simulation technology used for education within your program?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Clinical (procedural skills)? How many hours are spent on each skill?</td>
<td>e.g. arterial blood gases, suctioning, securing artificial airways, bronchoscopy, manual ventilation</td>
</tr>
<tr>
<td>B. High stakes skills training?</td>
<td>e.g. high risk procedures including endotracheal intubation and tracheostomy tube changes/insertions</td>
</tr>
<tr>
<td>C. Team based training?</td>
<td>e.g. rapid response team, code blue team</td>
</tr>
<tr>
<td>D. Problem-based learning?</td>
<td>e.g. collaborative group learning through problem solving</td>
</tr>
<tr>
<td>E. Case studies?</td>
<td>e.g. care of a patient with vital signs, history, signs and symptoms</td>
</tr>
<tr>
<td>F. Interdisciplinary training?</td>
<td>e.g. working with other professions in simulation (nurses, physicians, physiotherapy)</td>
</tr>
<tr>
<td>G. Soft skills?</td>
<td>e.g. professionalism, teamwork, communication, critical thinking, troubleshooting, handover report</td>
</tr>
<tr>
<td>H. Evaluation?</td>
<td>e.g. performance assessment</td>
</tr>
<tr>
<td>I. Which patient populations?</td>
<td>e.g. Adults, pediatric, neonatal</td>
</tr>
<tr>
<td>What steps, if any, do you take to enhance environmental realism and psychological realism during simulation use?</td>
<td></td>
</tr>
<tr>
<td>Do you provide a debriefing or critique after a simulation exercise? Can you describe what this looks like?</td>
<td></td>
</tr>
<tr>
<td>What kind of time frame do your students have between mastery of the skill in simulation, and clinical practice on a patient?</td>
<td></td>
</tr>
<tr>
<td>Can you describe how simulation is used for evaluation in your courses?</td>
<td></td>
</tr>
<tr>
<td>(if used for evaluation) How is performance measured?</td>
<td></td>
</tr>
<tr>
<td>(if used for evaluation) What quality assurance measures do you take to ensure consistency and standardization?</td>
<td></td>
</tr>
<tr>
<td>What challenges have you encountered during the incorporation of simulation into your course curriculum?</td>
<td></td>
</tr>
<tr>
<td>What, in your opinion, are the benefits to incorporating simulation into the courses you teach?</td>
<td></td>
</tr>
<tr>
<td>How do you see the use of simulation technology evolving in this program?</td>
<td></td>
</tr>
<tr>
<td>In absence of financial considerations, what changes or additions would you want to make with simulation technology in your courses or the program overall?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Sample observation guide

Student Observation Sessions – Observer Notes

Number of students __________ First year/Second year/Third year

Date ________________________________

Student Code Numbers:

Skills or competencies

Are they performing high-risk activities?

Are they gaining experience with rare skills they won’t see in clinical placement?

Are they training for scenarios that may put them at risk?

Are they doing any team-based training?

Are they making decisions, solving problems, using critical thinking?

Are they learning teamwork, ingenuity, communication skills?

What kind of simulation technology equipment is in use?

What levels of equipment fidelity?

What levels of environment fidelity?

What levels of psychological fidelity?

Deliberate practice theory


–repetition and refinement?
Zone of proximal development

-how much is instructor involved? –conscious internal guidance? –internalizing process?

Activity theory

- are students on the sidelines learning/absorbing as they are immersed?

Social theory

- is there behaviour modeling? Are students paying attention? Are they reproducing the behaviour? – any cavalier behaviour?

Scaffolding theory

- are the students building on previous concepts?

Behaviourism – Cognitivism – Constructivism - Debriefing

- Are purposes or objectives stated, or lacking?
- Friendly and confidential learning environment, or domineering?
- Questions encouraged?
- Errors encouraged and learned from?
- Correction of errors and critique? Excessive criticism or negativism?
- Highlighting key teaching moments, or excessive points?
- Visual aids to review concepts or actions?
- How long is the debriefing?
Appendix E

Code frequency report

<table>
<thead>
<tr>
<th>Code</th>
<th>Total</th>
<th>Bar Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliberate practice theory</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>High-risk procedures</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Low fidelity</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Psychological fidelity</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Part task trainers</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Neonatal or Pediatric</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Curriculum integration</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Assessing need for simulation</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Disadvantages with simulation</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>High fidelity</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Intermediate fidelity</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Simulated patient – RT student</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Debriefing</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Patient safety</td>
<td>26</td>
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<tr>
<td>Confidence</td>
<td>24</td>
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</tr>
<tr>
<td>Future</td>
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<tr>
<td>Code blue</td>
<td>21</td>
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<tr>
<td>Mechanical ventilation</td>
<td>22</td>
<td></td>
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<tr>
<td>Scaffolding</td>
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</tr>
<tr>
<td>Physical assessment</td>
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<tr>
<td>Team training</td>
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<tr>
<td>Interdisciplinary training</td>
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<tr>
<td>Anatomy</td>
<td>16</td>
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</tr>
<tr>
<td>Cavalier behaviour</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Comparing simulation technology</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Competence</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Difficulty with simulation</td>
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<td></td>
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<tr>
<td>Instructor training</td>
<td>16</td>
<td></td>
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<tr>
<td>Peripheral participation</td>
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<td></td>
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<tr>
<td>Problem–based learning</td>
<td>16</td>
<td></td>
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<tr>
<td>Advantages with simulation</td>
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<tr>
<td>Critical thinking</td>
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<td>Errors</td>
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<td>Switching roles</td>
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**Total:** 69  
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Appendix F

Code map