The Dissertation Committee for Robert Williams Ellis Certifies that this is the approved version of the following dissertation:

Examining the Experience of Performance Anxiety and Cognitive Load by Medical Residents In A Simulation

Committee:

Diane L. Schallert, Supervisor

Marilla D. Svinicki, Co-Supervisor

Cindy Carlson

Toni L. Falbo

Jean Carole Taxis

Examining the Experience of Performance Anxiety and Cognitive Load by Medical Residents in a Simulation

by

Robert Williams Ellis, A.B.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

December 2016

Dedication

To all members—past and present—of the Dissertation Support Group.

Acknowledgements

No journey of this scope occurs without important assistance and contributions from others invested in the outcome and its author. I extend abundant gratitude to Dr. Diane Schallert as chair of my committee. Her expertise, perspective, and energy as both an important scholar and a good friend have made this dissertation possible.

The limited space here cannot possibly capture the extent of my thanks for Dr. Marilla Svinicki, co-chair of my committee and wise guide, not only in this research, but also throughout the whole of graduate school. At every turn her vision, understanding, insight, knowledge, capability, assistance, and encouragement have shone as a beacon on even the most storm-tossed portions of the voyage.

I would also like to thank my committee members, Dr. Cindy Carlson, Dr. Toni Falbo, and Dr. Carole Taxis. Stalwart and sagacious, these leaders represent the finest traditions of academic achievement, development, and dissemination that promotes future generations of intellectual contributors and the growth of their fields.

Fundamental to achievement in this endeavor has been the Department of Educational Psychology at The University of Texas at Austin for providing an opportunity to reach for the dream of an advanced degree. Particular lauds extend to the invaluable, unwavering, and ever-present support, through all facets of the graduate school process, provided by Pam Larick and her predecessor, Virginia Stockwell.

Navigating the challenges inherent in any research of human subjects would not have been possible without the generous, welcoming, and masterful assistance of Jeffrey Eaton, M.D., Christopher Stearns, M.D., and Marianne Mowbry, R.N., who have been crucial in helping me establish and conduct research in medical education. Their patience, experience, and support have been vital in achieving completion of this dissertation. Additional thanks extend to Celina Mankey, M.D., and Beth Miller, M.D., whose introductory guidance helped germinate the idea for this research.

Throughout this process I have been exceedingly fortunate to enjoy the support and encouragement of family, especially from my mother, Mary Dare Ellis, M.A. and my father, Oren Henry Ellis, M.D., whose tutelage, mentoring, and abiding love have always celebrated education and the compassionate human impulse to care for the health of others. I am also grateful for the championing and alliance of my sister Barbara Brown, and my brothers Mike Ellis, Stewart Slatton, and Bruce Slatton, as well as that of their extended families.

I would be remiss not to acknowledge two significant contributions to my health throughout this venture, one an individual, and one a group. The work of Dr. Laura Ebady has been profoundly transformative in my own psychological journey, fostering the awareness that understanding others necessitates understanding oneself. Likewise, the advice and care from the Dissertation Support Group has proven immeasurable: All doctoral candidates should be fortunate to have such great counsel.

Last, but by no means least, I thank the dearest, most incomparable friends who have stood with me in resolute and loving solidarity throughout this process, often believing in me even when I failed to do so. To Jason Chayes, Caitlin McClune, Derek Groothuis, Steve Schnack, Chuck Bontrager, Christian Côrrea, Shawn Olsen, Dr. Kris Wiley, and Lt. Col. James DeBoer, I tender the highest possible thanks, admiration, and love. In them I recognize daily the sentiment expressed by the artist Berkley Breathed: "I got the best friends in all of explored space!"

Examining the Experience of Performance Anxiety and Cognitive Load by Medical Residents in a Simulation

Robert Williams Ellis, Ph.D.

The University of Texas at Austin, 2016

Supervisors: Diane L. Schallert, Marilla D. Svinicki

Medical education increasingly incorporates simulations as a method of instruction, but further research about simulation development, use, and efficacy remains necessary. This study, which took place in a teaching hospital, surveyed medical residents on an Internal Medicine rotation about the experience of performance anxiety and cognitive load during a simulation exercise. Statistical significance was discovered in the means of self-reported performance anxiety pre- to post-simulation, and the factor of cognitive load was found to have a moderate correlation with post-simulation performance anxiety, though caution should be exercised considering the statistics owing to small sample size. A physician-faculty member and a resident nurse reported observations about the simulation exercises and the residents, highlighting questions of standardization of simulation use, the role of simulations as a curriculum component in medical education, and the importance of communication during simulation. Future areas of research are recommended for factors such as refinement of cognitive load measures, multiple cognitive load measure types, and the presence of additional factors in simulation experience such as demographic variation. Suggestions for practice include customization of simulations for specific learning environments, populations, and goals,

as well as increasing emphasis on simulation for training in both medical content knowledge and social and psychological interaction.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Since their inception, simulations have been used as instructional and assessment tools in training and education settings, but their advent has prompted questions about their applicability, investment, and, of course, efficacy. Increasingly, the fields of medicine and medical education have incorporated simulations to teach practical medical knowledge, skills, and procedures (Bashankaev, Baido, & Wexner, 2011). However, the global medical community has recently demonstrated increasing interest in the science of learning, a field that seeks to understand the how and why of teaching for learning. Long established as practitioners of evidence-based health care, the medical faculty has begun to ask more questions about the evidence behind the ways medicine is taught and learned. More and more they are looking for effective ways to structure their educational practice (American Medical Association, 2013). As simulations increasingly appear in many aspects of medical education, so do investigations into the role that simulations play, how they change medical education, and whether or not they can be used effectively to measure performance that will later transfer to actual, live patients in a clinical setting (Schout et al., 2010). Because the use of simulations is similar in nature to many of the performance situations that are studied in other educational venues and in cognitive research on human learning and performance, the medical education field can take constructs from these areas and use them to help interpret the effects, benefits, and drawbacks of using simulations for their teaching and assessments. In the next section, I provide a brief background about some of the issues important as context for the present study. Then I offer a rationale for my specific study, and organize the broad research questions underlying my research. Finally, I describe the basic structure of this document.

BACKGROUND CONTEXT FOR THE PRESENT STUDY

A long-standing tradition in medical education has been the apprenticeship model, sometimes characterized as the "see one, do one, teach one" method (Maran & Glavin, 2003; Schout et al., 2010). In this model, medical students observe a particular procedure by a skilled practitioner, perform that same procedure under supervision, and then attempt to teach that same procedure to a fellow student. Part of this model includes an emphasis on guided exposure to the content knowledge and skills as a way to reinforce learning. Although simulations are increasingly considered as an additional way to produce the same effect more efficiently, universal adoption of simulators has yet to occur (Cook, Hamstra, Brydges, Zendejas, Szostek, et al., 2013; Maran & Glavin, 2003; McGaghie, Issenberg, Petrusa, & Scalese, 2016). Questions remain as to whether the apprenticeship model should be replaced, or merely supplemented as medical education evolves to incorporate a variety of techniques and technologies, including repetitive simulation practice combined with focused feedback.

Compounding the difficult questions of simulator efficacy and applicability, the dynamic socio-political and economic landscape of contemporary health care provision continues to change, bringing to the fore issues of training, time investment, financial costs, and personnel allocation that permeate discussions about health care and education in health-related professions (Okuda et al., 2009). Underlying any considerations of the financial, temporal, and human labor impact of incorporating simulations into a medical curriculum lie foundational questions about whether simulations work as teaching and assessment tools, and if so, to what degree and under what specific conditions (Laschinger et al., 2008). Opportunities remain to evaluate not only the effect of simulations on learning outcomes, but also the impact of various simulations relative to their cost. Simulations are tools, and the questions surrounding them are similar to those about any tool in an educational setting: What does it do? How is it used? How effective is it? What outcomes occur? Under what conditions, and for whom, is it effective?

Likewise, opportunities also exist for examining the impact of various simulations relative to factors of cost, availability, ease of use, and specialization also exist (Cooper & Taqueti, 2008). It may be that the advanced educational tools of medical training demonstrate different degrees of effectiveness relative to where and when they are used. Are simulations effective in medical school, in clinical residency, and in continuing education, and if so, which ones are more useful in which settings? Should medical simulation (and any educational simulation, for that matter) occur earlier in students' education than the post-secondary setting, or what benefits accrue to users of simulation training at later times in their career? What is the difference in simulation effectiveness relative to cost, and what role does fidelity play in how simulations are used, understood, and evaluated? Because not all hospitals are the same, not all simulations are the same, and not all instructional methods are the same (to say nothing of the significant diversity in faculty and students), studies about the efficacy of simulations should consider the setting as well as the instruments.

Finally, an important consideration in the development of simulation research is the focus of each simulation. Some simulations are designed to develop specific, precise skills such as surgical accuracy, for example (Bashankaev et al., 2011). Other simulations may be used to examine or develop interprofessional teamwork on an emergency room code scenario (Garbee et al., 2013), and such studies that engage with the psychological experience of a simulation are of particular interest. The learner and the context are important variables that have long been a significant focus in many other areas of educational research from mathematics (Ashcraft & Moore, 2013) to music (Ryan & Andrews, 2009). This intersection of psychology and simulation is of particular interest, and approaching simulation research with questions about the individual human experience, cognitive processing, motivation, and emotion represents an important area of medical education research.

RATIONALE FOR THE PRESENT STUDY

This study examined the experience of medical residents undergoing simulation assessment at a teaching hospital in a large southwestern city in the United States. Of the many questions that could be asked in this growing and active field, this study focused on the experience of performance anxiety and cognitive load reported by medical residents relative to a simulated medical task. Specifically, this study examined variation in performance anxiety levels prior to and immediately after the simulated medical circumstances. The study also queried participants about their experience of the external factor of cognitive load as a function of the simulation itself. Finally, the study incorporated contextual commentary and observation from a physician-faculty member and a registered nurse involved in conducting, overseeing, and evaluating the simulation exercise as part of the curriculum for the medical residents. These components provided insight into the experience of medical residents undergoing simulation training in an Internal Medicine rotation at a teaching hospital. Specifically, the study gathered data about performance anxiety, cognitive load, simulation fidelity, and observed behaviors during a simulation replicating atrial fibrillation, which is a common medical condition encountered daily by health care professionals in hospital settings. Results of the study not only point to avenues of future research, but also spark questions about the nature of medical education and medicine as multi-dimensional professions with increasingly complex conditions, behaviors, components, and areas of applicability.

RESEARCH QUESTIONS

I was guided by three major research questions, two of which are divided into three subquestions each. The first research question was: What was the level of pre-simulation performance anxiety, perception of cognitive load, and post-simulation performance anxiety that residents experienced during a simulated medical consultation? The second research question was: What were the relationships between the two collections (pre vs post) of performance anxiety, as well as their relationship to the perception of cognitive load? The third research question was: How did the residents, the researcher, and professionals working with the simulation describe the development of the simulation and their observation of the residents as they were experiencing the simulation? The subquestions for the first and second research questions have to do with the reported levels of the constructs of performance anxiety and cognitive load, as well as the variability and relationships between the factors. These subquestions are outlined in greater detail at the end of Chapter 2.

ORGANIZATION OF THE DOCUMENT

In this introduction, I have introduced the study, provided a brief background for context, as well as a rationale for the research project and the research questions underlying the collection and analysis of relevant data. In Chapter 2, I outline some pertinent literature about simulations and medical education, as well as theoretical constructs of performance anxiety and cognitive load. I conclude the chapter with a detailed list of the study's research questions. Chapter 3 describes the research methodology undertaken for the project, including some limitations, protocols for protection of participant anonymity and confidentiality, and analysis procedures for the data. In Chapter 4 I review the results of both the quantitative and contextual data gathered, before proceeding to Chapter 5, in which I review some of the limitations, discuss some findings, and propose content for medical education practice and future research endeavors.

Chapter 2: Review of the literature

Background

Although simulators in medicine are a more recent development, the use of simulators as training tools to develop specific applied skills dates back to the early days of aviation in the first quarter of the 20th century (Koonce & Bramble, 1998). As aviation technology evolved, so did the means to simulate flight in a variety of conditions and to evaluate pilot skills handling them (Bashankaev et al., 2011; Koonce & Bramble, 1998; Okuda et al., 2009). Observing aviation's success in reducing errors in critical performance by using simulators, other professions and fields began to speculate on the suitability and application of simulation in training in their own circumstances of varied risk.

In medicine, the development of mannequin simulators for use in training clinical skills such as mouth-to-mouth pulmonary resuscitation and anesthetic administration dates back to the 1950s (Laschinger et al., 2008; Okuda et al., 2009) or 1960s (Cooper & Taqueti, 2008), and other technologies such as surgical tool partial task trainers and computer simulations followed (McNaughton, Ravitz, Wadell, & Hodges, 2008). The increasing presence of simulators in medical education has grown since the late 1970s (Bashankaev et al., 2011; Laschinger et al., 2008) and simulators are now used in both undergraduate and graduate levels of medical training (Okuda et al., 2009).

Simulations in medical training

Simulations in medical and nursing education have taken a variety of forms ranging from low to high fidelity, including (but certainly not limited to) games, paper-and-pencil case-based problem-solving, standardized patients, cadavers, computer-based testing, complex electro-mechanical mannequins, computer-assisted virtual reality systems, and environmental simulators (Bandali, Parker, Mummery, & Preece, 2008; Bashankaev et al., 2011; Cant & Cooper, 2009; Cooper & Taqueti, 2008; Davoudi & Colt, 2009; Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005; Maran & Glavin, 2003; May, Park, & Lee, 2009; McNaughton et al., 2008; Okuda et al., 2009). The goal of simulation training is to create a learning environment that mimics as closely as possible—but only to the level of sophistication actually needed—the process and experience of working with an actual living patient (Cant & Cooper, 2009; Maran & Glavin, 2003). As medical processes have advanced, so too have the skills and knowledge to effectively deliver those processes in the successful treatment of patients (Issenberg et al., 2005). Simulation may provide methods of instruction that emphasize development of such technical skills and knowledge without the risks involved in learning them (Issenberg et al., 2005). Other possibilities for future use of simulators in medical education are in the areas of assessment, certification, credentialing, and analysis of medical-legal issues (Okuda et al., 2009).

Simulation types

While by no means an exhaustive survey, the following brief overview discusses four types of simulations that may be found in contemporary medical education: *the partial task trainer, the mannequin, the computer simulation,* and *the standardized patient*. Not all these simulations are in use throughout medical education, as adoption of simulations is not universal, and it remains important to remember that simulations are regarded as a supplement to, but not a replacement for, clinical training (Laschinger et al., 2008).

The partial task trainer.

The partial task trainer is a device or exercise that focuses on one skill or knowledge for a particular medical activity, or on a small selection of skills or knowledge that form part of a larger procedure (Cant & Cooper, 2009; Cooper & Taqueti, 2008; Laschinger et al., 2008). For example, the "ex vivo knot tying board" (Bashankaev et al., 2011, p. 29) is a simple, flat surface fitted with surgical tubing that novice laparoscopic surgeons have sometimes used in the past to practice the delicate task of tying surgical knots (Bashankaev et al., 2011). Although the board does not instruct on all features of laparoscopic surgery, it does allow students to develop a particular, precise skill of surgical manipulation applicable to many laparoscopic surgeries (an example of laparoscopic surgery would be an appendectomy).

Mannequins.

The mannequin is a simulation tool designed to represent a life-size and—to varying degrees life-like—human body (Cant & Cooper, 2009; Laschinger et al, 2008). Mannequins come in several varieties, including partial mannequins that typically comprise a head and torso, such as may be used in cardio-pulmonary resuscitation (CPR) training (Cooper & Taqueti, 2008). Mannequins also come in full body varieties that have limbs, and very high-fidelity models may include extensive and intricate components including "airway anatomy…palpable carotid and radial pulse…heart and breath sounds, eyes that opened and closed," (Cooper & Taqueti, 2008, p. 566), and more. Mannequin simulators can be used for a broad variety of instruction in many areas, including but certainly not limited to anesthesia, intubation, intravenous insertion, code response, and surgery, (Cooper & Taqueti, 2008; Issenberg et al., 2005).

Computer simulation.

The computer simulation involves training through interaction with a computer and applicable software. As with mannequins and partial task trainers, computer simulation can take a variety of forms, but typically involve a student working at a computer screen as part of the instruction. For example, a computer simulation may show features of internal human anatomy for use in practicing endoscopic surgery techniques (Issenberg et al., 2005). Some computer systems incorporate on-screen information and interaction with other devices such as partial-task trainers or mannequins (Bashankaev et al. 2011).

Standardized patients.

Likewise, the standardized patient is a practiced and recognized method of instruction designed to represent interaction with an actual patient. Effectively present in health care settings since 1963 (Rutherford-Hemming & Jennrich, 2013), standardized patient simulation involves living actors portraying patient roles (Marken, Zimmerman, Kennedy, Schremmer, & Smith, 2010). An advantage of the standardized patient as simulation lies in the opportunity for students not only to work with a living body, but also to experience the emotional and psychological processes and behaviors that may present in live patients (Rutherford-Hemming & Jennrich, 2013). As Rutherford-Hemming and Jennrich note, "Through the use of standardized patients, simulation experiences provide a foundation for the nurse's first encounters with actual patients" (2013, p. 118). Furthermore, Grice, Wenger, Brooks, and Berry (2013) reported a success rate of 95% among pharmacy students learning physical assessment of individuals using standardized patients in the instruction. From their research, Grice et al. (2013) concluded that standardized patients and mannequin training represent equally effective methods of teaching physical assessment, though it is important to note that students in the study reported a preference for working with standardized patients.

Simulator sophistication and learning

Simulators can also be used to support learning environments that capitalize on multiple features desirable for learning. Issenberg et al. (2005) and Davoudi and Colt (2009) suggested 10 such features, among which are feedback, repetitive practice, clinical variation, and simulator validity. The degree to which the appearance, behavior, function, and impact on the student a simulator replicates the actuality of practice with real living patients is the mark of a simulator's level of fidelity (Maran & Glavin, 2003; Okuda et al., 2009).

Simulation sophistication is one of the areas in which questions about technological efficacy arise. As simulators increase in technological sophistication, their costs are also likely to increase. By corollary, as simulators increase in technological sophistication, the range of procedures and conditions they can simulate also increases (Bashankaev et al., 2011). Some simulators can provide tactile feedback or can accommodate actual organic tissue specimens (Bashankaev et al., 2011). Feedback is another important aspect of the process of skill development and knowledge acquisition in medical education (Maran & Glavin, 2003; Okuda et al., 2009), and some simulators now incorporate systems that can provide, for example, scoring on metrics of performance (Bashankaev et al., 2011). Cant and Cooper (2009) also cited the intersection of simulator tools with feedback and debriefing as an important feature in the application of simulators in clinical education.

Financial issues and simulation

A core issue that arises from any discussion about incorporation of technology is the financial requirements necessary to put a given technology into place. The gradual introduction of simulators in medical education has been possible in no small part due to advances in science and technology (Bashankaev et al., 2011; Okuda et al., 2009). Such advances often incur substantial monetary costs; indeed, medical education itself is a significant financial investment (Bashankaev et al., 2011; Cooper & Taqueti, 2008), so the questions arise, at what point do educational costs and new technology costs intersect, and can such an intersection maximize the educational advantages and the financial investment they require? In their review of simulators, Bashankaev et al. (2011) noted that simulators may provide a teaching tool to help offset some of the increased costs that may be associated with current medical resident training, including risks to patients related to increased hospital stays or prescription medication errors (to name just two).

Simulators with advanced features can sometimes cost tens or hundreds of thousands of U.S. dollars (Davoudi & Colt, 2009), but technological advances can also mean long term cost reductions for some systems. For example, units that can connect to desktop or laptop computers and provide a virtual reality training environment in cooperation with standard commonly available computer operating systems and sufficient graphics hardware (Bashankaev et al., 2011). Such systems can potentially transform a medical student's desktop office space into a training environment for clinical skill and knowledge advancement.

One of the disadvantages of such systems, however, is that many current virtual reality simulators do not allow teams of students to work together, a condition absolutely requisite in many areas of health care provision, including surgical and emergency medical training (Bashankaev et al., 2011; Marshall & Flanagan, 2010). In their review, Bashankaev et al. (2011) noted that the field of medical education appears ripe to take advantage of simulators by combining multiple simulation types and systems, or at least providing environments in which students have access to a variety of simulators to represent better the complexity of patient biology. Another option for managing costs of technology is centralizing training at facilities specifically established to house simulators (Bashankaev et al., 2011). Such facilities might provide standardized simulation training for institutions and medical populations that may not have access to sophisticated levels of technology or the funds required to purchase and maintain them (Bashankaev et al., 2011). Centralized training locations, however, also have disadvantages, as students would have to find time to travel to them and incur relevant financial costs, for example (Bashankaev et al., 2011). Although there has been vocal support for the increased use of simulators in surgical training (Bashankaev et al., 2011), more research remains to be done on the overall utility of simulators relative to the training task and cost of implementation.

ADVANTAGES OF SIMULATORS AS TEACHING TOOLS

An advantage of the simulator as a teaching tool is in the opportunity such a tool affords inexperienced clinical practitioners to develop some of the skills necessary for accurate, timely, and successful treatment for live patients. Simulators allow the development of these critical skills to take place in an environment that cannot harm a living patient and that can be practiced frequently (Bashankaev et al., 2011; Cant & Cooper, 2009; Davoudi & Colt, 2009; Hilty et al., 2006; Kneebone et al., 2003; Maran & Glavin, 2003). Okuda et al. (2009) described the complexity of some of the learning conditions and features relevant to many medical skills, including psychomotor skills that may seem simple but “require the integration of problem-solving skills, communication skills, and technical skills in the setting of a complex medical context” (p. 333).

Critical to the achievement of technique expertise is attention to four areas: intense repetition, assessment of performance, specific feedback, and controlled improvement (Okuda et al., 2009). If medical students arrive at their first live patient with a measure of advanced simulated experience that will have steadily built up their skill and knowledge base, the ultimate outcome for live patients may be safer and better (Bashankaev et al., 2011). Such build up may also have implication for the long-term reduction of some medical costs for institutions.

HEALTH CARE INTEREST IN SIMULATORS

One reason for an increased interest in simulators as clinical teaching tools has been growing concern within the health care industry in a number of nations regarding rates of medical error resulting in harm (up to and including death) to patients (Bandali et al., 2008; Bashankaev et al., 2011; Issenberg et al., 2005; Kohn, Corrigan, & Donaldson, 1999). As part of curriculum evaluation and change made in hopes of addressing the worrisome statistics regarding medical error, many institutions hope that the inclusion of a number of different initiatives, such as interprofessional team development and simulation practice for skill improvement, will improve health care professional preparation for the workplace (Bandali et al., 2008; Cant & Cooper, 2009; Okuda et al., 2009). Simulators represent one opportunity for medical schools and clinical teaching settings to provide future (and current) health care professionals with increased exposure to practice skills necessary for contemporary provision of health care (Bandali et al., 2008; Bashankaev et al., 2011; Cant & Cooper, 2009). Such skill development intersects with another concern in medical education as institutions note a decrease in available clinical placement for students (Bandali et al., 2008), reduction in resident work hours (Bashankaev et al., 2011), and the pressures of managed care to emphasize shorter hospital stays (Issenberg et al., 2005). The changing landscape of medical provision in the United States alone has demonstrated an increased need for skill and knowledge training among clinical practitioners to meet diverse medical needs and emphases (Issenberg et al., 2005; Laschinger et al., 2008; Maran & Glavin, 2003; Okuda et al., 2009). As medical education incorporates increasingly sophisticated technology into increasingly broader curricula the need for research into the efficacy of simulations relative to their availability and accessibility also increases (Laschinger et al., 2008).

SIMULATOR EFFICACY

Of course, interventions using simulators as teaching tools—and the recommendations that may appear in their wake—require a measure of caution. The literature on simulators and their effects on learning outcomes includes conflicting reports (Laschinger et al., 2008). Cooper and Taqueti (2008) reported that a survey of results in mannequin simulator research found only limited learning transfer in simulation-supplemented education. In addition, research into the effectiveness of simulators as teaching tools should include future investigation into long-term simulation use as part of a learning environment, whereas many studies simply look at simulation use in single or short-term occasions (Cooper & Taqueti, 2008). Laschinger et al. (2008) found a number of studies that supported knowledge increase and retention shortly after a simulation training exercise, but long-term retention of knowledge declined many weeks later. In the case of skill training, some studies have reported short-term improvement using high-fidelity simulators whereas other studies have found no evidence of improvement in skill development after use of simulators (Laschinger et al., 2008). Still further studies have reported that the longer periods or increased frequency of technique practice using simulators corresponds to improvement in learner outcomes (McGaghie, Issenberg, Petrusa, & Scalese, 2006). Examinations of the effects of simulators on self-confidence of medical students have also showed variability, and tend to depend on self-reports by students, which may fail to ensure sufficient objectivity (Laschinger et al., 2008).

By contrast, Davoudi and Colt (2009) cited numerous examples of research (specifically in the area of simulations used in training students to perform bronchoscopies), in which even short-term training sessions improved bronchoscopy skills, and multiple sessions of longer training also demonstrated improvement among medical students for skill development. In their review of studies examining the role that educational games have on medical student learning outcomes, Akl et al. (2010), noted that the literature thus far has reported inconsistency in the results of such studies. For example, Schout et al. (2010) cited the concern among some researchers that students may develop expertise on a simulator but not necessarily in the actual clinical circumstance for which the simulator is designed to train. As Hilty, et al. (2006) carefully observed, "It is all too easy to become overly enamored with particular kinds of electronic wizardry and forget that all educational technology is fundamentally dependent on the underlying pedagogy and learning principles employed to deliver the educational programs themselves" (p. 528), a sentiment echoed by others (Maran & Glavin, 2003).

Importance of methodology to simulator efficacy

The importance of simulators as enhancements to medical education must naturally incorporate the importance of the methodology in which they are used and the instructional techniques and effectiveness of those who employ them (Issenberg et al., 2005; Schout et al., 2010). It is also important to note that simulation education does not replace education of medical practitioners with actual living patients (Issenberg et al., 2005), but use of simulators in medical learning is unlikely to diminish or disappear (Okuda et al., 2009). As has been noted (Akl et al. 2010; Laschinger et al., 2008; May et al., 2009; Takayesu, Nadel, Bhatia, & Walls, 2010), the need for additional research remains paramount if the murky verdict on simulators as teaching tools in medical education is to see an increase in clarity.

NEED FOR MORE EDUCATIONAL RESEARCH

The inevitable increase of simulation training in medical education and development demands research in order to determine best use of the technology. Ultimately, simulation is a tool—a teaching tool—and tools are only as good as the instructors who employ them in the service of advancing the experience, ability, and practice of future professionals. Kneebone et al. (2003) reiterated the need to properly use simulations properly as an instructional component in order to maximize the benefits (if any) that they provide. The same variables that are being studied in other educational settings should be examined in the simulation setting. By looking at basic learning processes and how they respond in the simulation environment, simulation research can make use of what is known about such variables and build on that knowledge to move simulation research along more quickly. In the next section, I discuss two important variable realms that are typical in educational research, but that have not been studied in medical simulation as a learning tool: the state of the learner and the difficulty of the task.

VARIABLES AFFECTING RESIDENT PERFORMANCE DURING SIMULATION PRACTICE

In terms of individual variables affecting performance in simulations, two that have been studied in other performance contexts could prove to be significant factors in simulation performance. Specifically, *performance anxiety,* a condition of the learner, and *cognitive load,* a condition of the task, have been studied in a wide variety of different learning and evaluative contexts beyond medical education, including language learning (Birjandi & Alemi, 2010), flight training and evaluation (Sloan, Lundin, Wilson, & Robinnette, 2010), and among medical clerkship students (Reteguiz, 2006). Their effects on performance in a simulator task are important to understand if learning in these simulations is to be maximized.

First, performance anxiety is a learner variable that needs to be examined. Its effect has been shown to be significant and detrimental in a wide range of learning situations. However, its effects on skilled performance in pressure situations are less well understood and very relevant to the usefulness of simulations as instructional and assessment measures. This variable is discussed in more depth below.

In terms of situational variables that influence performance, cognitive load is a prominent theory (CLT) in educational research, and has been studied in several areas (Linnell & Caparos, 2011), including nursing (Hauber, Cormier, & Whyte IV, 2010) and medical education (van Merriënboer & Sweller, 2010). However, measuring cognitive load can be difficult (Paas, Tuovinen, Tabbers, & Van Gerven, 2003) and researchers are still searching for a reliable way to classify situations in terms of cognitive load. CLT remains an important area to study, however, especially at the intersection of simulation exercises and assessment in medical education (Hauber et al., 2010). Because increased cognitive load in a situation is possibly one trigger for performance anxiety and therefore potentially detrimental to performance, the intersection between the two has promise for informing simulation design and use.

This study focuses primarily on these two variables: Performance Anxiety, and Cognitive Load, and their impact on resident performance. The next section will discuss some background information about these variables of interest.

Performance anxiety

Anxiety is generally acknowledged as an unpleasant, subjective, emotional and psychological experience in individuals characterized by such qualities as nervousness, tension, apprehension, and worry (Reteguiz, 2006; Shokrpour, Zareii, Zahedi, & Rafatbakhsh, 2011; Vitasari, Wahab, Othman, Herawan, & Sinnadurai, 2010). Anxiety's effects on individuals include such features as panic, "blanking" during testing or assessment or prompted response, sweating, increased breathing and heart rates, and upset stomachs (Vitasari et al., 2010). Anxiety can even express in a potency that impacts quality of life (Vitasari et al., 2010). Anxiety is recognized in numerous circumstances of learning, and has been a prominent and important focus of study across a broad range of fields, demographics, and settings, including language learning (Birjandi & Alemi, 2010), flight training and evaluation (Sloan et al., 2010), and medical clerkship students (Reteguiz, 2006). Because anxiety has been shown to have a detrimental effect on student performance in a wide range of evaluative situations (Vitasari et al., 2010), it makes sense to examine the simulated environment or scenario in medical education as yet another possible arena in which anxiety might be present and contribute to variation in student outcomes. Thus, the specific focus of this study is performance anxiety, which is defined as a "persistent, irrational fear of exposure to scrutiny in certain situations, particularly . . . dramatic, or other types of performances" (Doctor, Kahn, & Adamec, 2008, p. 379). Residents undergoing a simulation evaluated by a physician-faculty member would qualify as such a performance, and therefore would be likely to be susceptible to performance anxiety.

The scope of performance anxiety research in multiple learning environments far exceeds the limits of this study to encompass completely, thus this section will focus on literature pertaining to performance anxiety as a factor in medical education, with an emphasis on testing or performance anxiety in clinical settings. The prominence of performance anxiety in the experience of medical practitioners of all levels—including but certainly not limited to students—remains a significant factor in the lives of health care professionals, including effects on quality of life associated with factors such as depression, chemical dependency and abuse, social and relationship difficulties, impairment to learning, impacts on quality of patient care, and even suicide (Finkelstein, Brownstein, Scott, & Yu-Ling, 2007; Lee & Graham, 2001). Increasing demand for provision of high quality medical care has spurred growing examination of performance anxiety and stress factors in the lives of medical personnel (Finkelstein et al., 2007; Lee & Graham, 2001).

Performance anxiety in medical students.

Among medical students who are early in their course of study, anxiety may arise from several sources, including relative inexperience in medical practice and knowledge, financial burdens of medical education, and heightened work and study loads (Finkelstein et al., 2007). Those students undergoing the clinical component of their education have stresses and demands primarily centered on patient care and the medical provision environment (Lee & Graham, 2001). In one study examining an intervention introducing wellness training and awareness among medical students, researchers reported that although participants "acknowledged the importance of a physician's having a sound mind and body" (Lee & Graham, 2001, p. 657), many students nonetheless found it difficult to attend to their wellbeing and continued to battle medical school stresses (Lee & Graham, 2001). Furthermore, some study participants reported on a paradoxical, self-perpetuating condition of medical school stress and coping in which students felt guilty about taking steps to foster relaxation and self-care, which, in turn, only increased already significant stress levels (Lee & Graham, 2001).

Parallel to this self-perpetuating cycle of anxiety is another potentially complicating factor in the experience of medical students: the larger medical culture that has traditionally emphasized a kind of stoic and detached emotional response to many of the circumstances of medical care provision. For example, Casado, Castano, and Arraez-Aybar (2012) described the classic medical school component of basic human anatomy lessons, foundational to initial understanding of the very structures of a human body, how they operate, what they look like, and where in the corpus they appear. For many students, the dissection table is the first time they have seen a cadaver. For some people, the anatomy classroom is their first profound encounter with death (Casado et al., 2012). It is important to note that among the emotional responses this first experience of human mortality imparts, the most prominent is anxiety (Casado et al., 2012). The classroom environment, however, has traditionally emphasized and encouraged an emotional detachment or distance in the students under such circumstances. This emphasis has been suggested not only as a source for developing cynicism in future physicians, but also as a problematic approach to physicians confronting live patients in pain (Casado et al., 2012). In other words, what does it suggest to future doctors about dealing with live patients when, in essence, the first patient encountered by medical students is a corpse to be viewed with detachment as it is dissected? Further, what does it impart to students as part of the learning process about how to confront the highly emotional circumstances of medical care, not only for patients, but also for health care providers? Certainly, anxiety—including performance anxiety—of the learner falls into the category of emotional experience that must be navigated in some manner during the course of a physician's lifetime from classroom to clinic to courtroom.

Attention not only to the classroom setting and culture, but also to the clinical area of practice and education, has revealed the presence and significance of performance anxiety as a factor in the experience of medical students (Hayes et al., 2004). Transition from formal, traditional classroom to full-time clinical operations represents an important moment for medical students, but frequently represents an acutely stressful period in a long-term educational and developmental experience already marked by great stress. Central to the increase in anxiety-producing circumstances is the changing dynamic wherein the educational focus undergoes a metamorphosis from student-centered to the vital recognition of the ultimate, foundational medical outcome as patient centered (Hayes et al., 2004). The familiarity and relative safety of the classroom gives way to the clinical learning environment more frequently characterized by elevated intensity, chaotic and disparate circumstances, and the very real lives of those undergoing medical care. Suddenly, to learn is not merely to undergo edification of the self, but now intersects with, and includes, the potential lives and well-being of other humans.

Although introductory instruction in clinical skills has shown some reduction in student anxiety (Hayes et al., 2004), there remain more opportunities and need to investigate the experience of anxiety in students during various stages of medical education. Important to the question of changing educational circumstances and settings and the influence on anxiety is the detail of the students themselves, including their relative educational and experiential maturity (Hayes et al., 2004). In their anxiety self-report study conducted at a London, England medical school, Hayes and colleagues

(2004) found significant differences in reported anxiety between younger medical students and those who entered medical education at an older age. Nevertheless, the authors noted that age difference alone does not account for variance in anxiety, with other complicating and influential factors including differences in background education, differences in financial concerns, and fixed learning approaches. Of note from their study is the conclusion that continued training, skills development, and assessment throughout the clinical setting and beyond remain an important part to improving outcomes (and circumstances of performance anxiety) for medical students and practitioners, lending further support to the investigation into simulation as an additional mode of teaching and evaluation to bolster already robust methods in place.

Anxiety in simulation settings.

Anxiety can also surface as a specific, noticeable condition experienced by medical students in the context of simulation training and education. In their qualitative analysis of simulation-based teaching, Paskins and Peile (2010) reported the emergence of seven descriptive themes and five secondary themes from focus group participants, including the theme of Anxiety. Students expressed feelings of anxiety during simulation-based training using descriptors such as "'terror,' 'humiliation' and 'panicked'" (Paskins & Peile, 2010, p. 573). According to these researchers, "All of the individuals who mentioned anxiety reported positive learning outcomes, with some mentioning that the level of anxiety was possibly beneficial" (p. 573). However, the presence of anxiety, its expression, and its effects are not straightforward. Among the 28 students surveyed, not all reported anxiety. Those medical students that did indicate feeling anxiety frequently characterized it in terms of performance during simulation exercises in front of peers and faculty. In addition, some students reported that the simulation seemed "more stressful than a real-life emergency" (p. 575). These differing perceptions and descriptions among students undergoing the same simulation exercise point to the complexity of anxiety as a component in educational experiences and settings, as well as the diversity of the individuals within a given learning circumstance.

An interesting aspect of the relationship between anxiety and simulation training for medical personnel was mentioned by Harvey, Nathens, Bandiera, and LeBlanc (2010) in their study of medical students undergoing emergency procedure skill development at a Canadian hospital. Although research on stress has focused on chronic conditions, less scope and attention has turned to acute stress in specific medical procedure circumstances, and simulations may be one way in which training and/or testing for such specific procedures occurs (Harvey et al., 2010). Further, acute stress conditions in emergency medical circumstances may result in immediate negative effect on patient care, increasing the need to understand the presence and role that stress and anxiety play in medical practice—including education as preparation for practice, and as practice itself (Harvey et al., 2010). Students in the study were general surgery and emergency medicine residents in the postgraduate phase of their career, and all had undertaken trauma-specific life support training. The study was designed to examine stress responses and cognitive appraisal in simulated trauma events, and the participants already had some familiarity with the procedures and specifics for handling emergency medical situations. Two resuscitation simulation varieties were employed: *low-stress* (LS) and *high-stress* (HS), indicating relative levels of medical complexity and simulated patient stability facing the participants in the exercise. Hoping to determine if individual medical personnel appraisal of a given situation acted as a predictor of stress response, the researchers found a fascinating relationship between assessments of scenarios as "challenges" or "threats" and elevated cortisol hormone levels in the participants.

Residents estimating a given scenario as higher stress—or qualifying as having characteristics labeled a "threat"—tended to experience higher cortisol levels. The importance of the study lies in highlighting not only the usefulness of exploring simulation in medical education related to performance anxiety, but also in the use of simulation education to illustrate additional needs in overall medical education worthy of address. In the case of Harvey et al.'s study (2010), the simulation exercise highlighted the attention future educators may want to place on teaching students cognitive means of assessing dynamic trauma circumstances as a potential way to better manage stresses experienced during emergencies (p. 592-593).

COGNITIVE LOAD THEORY

The second important source of performance detriment that seems relevant to the present study is the concept of cognitive load. According to van Merriënboer and Sweller (2010), "Cognitive load theory (CLT) was initially developed in the 1980s" (p. 86). Cognitive load theory is concerned with focusing instructional components, exercises, and designs on substance relevant to learning, and minimizing the cognitive drain caused by unnecessary or irrelevant aspects of the learning circumstance (van Merriënboer & Sweller, 2010). In addition, learning apparatuses and structures designed to account for issues of cognitive load are an important feature to consider in educational settings that span increasingly longer time periods, including medical education (van Merriënboer & Sweller, 2010).

Cognitive load theory posits that human cognition has limits on how much active material can be engaged simultaneously in a given time period within immediate, more readily accessible memory (van Merriënboer & Sweller, 2010). Although this limitation of memory is a central aspect of CLT, it is important to note that CLT also emphasizes that it is novel information that is most susceptible to being lost from memory. Knowledge, information, and understanding already firmly established are not lost, regardless of whether or not that information or knowledge is present at the forefront of one's own cognition during a given learning experience or circumstance (van Merriënboer & Sweller, 2010). It is long-term memory wherein complex structures of knowledge and experience reside in sophisticated systems of organization called schemas (van Merriënboer & Sweller, 2010). According to CLT, the development and engagement of schemas is a kind of higher level cognitive activity that allows the translation of novel information in shorter-term memory to be incorporated into long-term memory, simultaneously establishing greater permanence and accessibility of such information and knowledge (van Merriënboer & Sweller, 2010). In other words, the development of expertise is the establishment and enhancement of schemas that enable an individual to take temporarily stored knowledge, information, or experience and transform it into long-term, resilient cognitive processes and structures that allow better, more efficient, more effective problem solving and task completion (van Merriënboer & Sweller, 2010). In order for an individual to have a better probability of successfully transforming new knowledge or experience into long-term, readily accessible and remembered material, learning environments must maximize access to certain kinds of information while minimizing exposure to less effective or relevant information.

Task variables related to cognitive load.

In CLT, components of a given learning exercise occupy one of three generally recognized categories: germane load, intrinsic load, and extraneous load (Fraser et al., 2012). Germane load is that portion of the circumstance or exercise in which an individual's working memory is dedicated to learning. For example, in a reading task, the information the text conveys would constitute germane load. Intrinsic load comprises those aspects of the learning design that "reflects both the inherent difficulty of a given task and the learner's prior knowledge or experience of the task" (Fraser et al., 2012, p. 1056). In the reading task example, the difficulty level of the reading itself would represent intrinsic load. Finally, extraneous load represents those components or features of the exercise that either do not contribute to learning, or that actively work against learning. Again, in the case of the reading task, unrelated images in the text would act as extraneous load. It is interesting to note that, depending on the design and presentation of the task, even the teacher can act as a source of extraneous load (Fraser et al., 2012). It follows, therefore, that in a medical simulation, the very components of the simulations themselves, including things such as mannequins and stethoscopes, could represent extraneous load, depending on the quality of the instructional design.

All three cognitive load components are considered additive: all aspects of cognitive load present in a given learning circumstance combine to tax the working memory of any individuals in the scenario, gradually diminishing learning (Fraser et al., 2012). It is therefore in the interest of academic institutions and instructors to develop learning tools and environments, including simulators, that maximize germane load while minimizing extraneous load, yet understanding that even excessive amounts of germane load can eclipse working memory and impede acquisition of new knowledge (Fraser et al., 2012).

Cognitive load cautions.

Any examination of CLT in the context of educational circumstances—particularly those that employ electronic technology—warrants consideration of potential problems with CLT as a theoretical and practical foundation. In their analysis of CLT research and principal components, Schnotz and Kürschner (2007) raised important concerns about CLT and various aspects of cognitive load in different learning situations. Although much attention has focused on research showing that high levels of extraneous load can impede learning, Schnotz and Kürschner (2007) pointed out the corollary that too little intrinsic load can also inhibit learning. Insufficient challenge in a learning task can adversely affect learning because the individual finds the task too simple or because too much information or help overcomes the psychological mechanisms that develop schema to meet tasks. The appearance of schema is one of the signifiers that learning has occurred in CLT (Schnotz & Kürschner, 2007); thus the absence of schema may indicate a lack of learning, which may occur if extraneous load overwhelms a learner, or if there is simply too little intrinsic load to engage the learner's inclination and ability to solve problems. Individuals of higher expertise are thus likely to learn more from a learning task with higher intrinsic load. It remains important, however, to remember that the various kinds of load outlined by CLT are not isolated. Although the student with greater expertise is more likely to learn from a task with higher intrinsic load, a correspondingly high amount of extraneous load will concurrently impinge on the learning. The relevancy of these factors points to the challenging circumstances facing medical educators intent on employing simulations as teaching tools. In order to design effective instructional components, medical educators must account for sufficient intrinsic load to capture the relevant level of student expertise while mediating (to the extent it is possible) those elements of extraneous load that can cloud working memory for those engaged in the learning task.

RESEARCH QUESTIONS

In light of the research and theories just reviewed, the purpose of this study was to examine the relationship between the situational variable of cognitive load and the learner variable of performance anxiety relative to the outcome of performance on a simulated medical procedure in a local hospital setting.

Research Question 1

What was the level of pre-simulation performance anxiety, perception of cognitive load, and post-simulation performance anxiety that residents experienced during a simulated medical consultation procedure using a technology enhanced mannequin?

Research Question 1a.

What level of pre-simulation performance anxiety did residents experience prior to the start of the simulation session?

Research Question 1b.

What level of post-simulation performance anxiety did residents report at the completion of a simulation session?

Research Question 1c.

What level of perception of cognitive load did residents experience during the performance of a simulation?

Research Question 2

What were the relationships between the two collections (pre vs post) of performance anxiety, as well as their relationship to the perception of cognitive load experience?

Research Question 2a.

Was there a change of reported performance anxiety as a function of having completed the simulation?

Research Question 2b.

Was the perception of cognitive load related to the pre-simulation performance anxiety?

Research Question 2c.

Was the perception of cognitive load related to the experience of post-simulation anxiety?

Research Question 3

How did the residents, the researcher, and professionals working with the simulation describe the development of the simulation and their observation of the residents as they were experiencing the simulation?

Chapter 3: Method

This chapter presents the methods for collecting and analyzing data in this study. Because the study changed over the course of data collection, the chapter begins with a discussion of limitations relevant to the setting of the study. The section on limitations includes the original projected aspirations for participants, as well as an overview of the final form of the data ultimately collected, illustrating the change from the original study idea relative to the final incarnation of the project.

LIMITATIONS IMPOSED BY THE SETTING

Before reviewing the methods of this study, a brief discussion of some important factors that defined the study will situate the methodology and research approach in context. This research took place in a teaching hospital in a large city in the southwestern part of the United States.

The effects of the ongoing instructional program on the study

Although the study and its results are anticipated to have benefit for the hospital faculty interested in questions regarding aspects of the their teaching methodology, the two principal and foremost duties of the hospital remain—and have always been—to provide medical care for patients and to teach future practicing physicians. As an ongoing instructional program, the hospital already had established curricula for the instruction of medical residents and interns, nurses, and other personnel, that continued uninterrupted during the course of the study. The simulation exercises observed during the course of the project were part of the ongoing teaching effort. Thus, the study was integrated into an existing framework, and, as the researcher, I recognized the importance of pursuing data in a manner that did not interfere with established protocols and practices of the teaching hospital. At no point did the study and its conduct threaten to impact negatively the ability of the teaching hospital and its faculty to instruct future physicians or to offer care for patients.

Because the study took place under the auspices of the hospital's procedures and oversight, I was not able to control which residents were available for data collection or participation in a simulation, nor was I able to dictate which simulations would be used during given instructional sessions, nor which faculty were available for participation, commentary, or interview in the research. Furthermore, one of the greatest challenges to overcome in any circumstance of human study was (and is) time. Any efforts to collect data were necessarily limited by the ability of medical residents, faculty, and support personnel to devote time to accommodate—and participate in—this study. As is so often the case in educational and human subjects research, this project could not exercise complete control over all variables influencing the process and outcomes, and although it was favorable to undertake this research with the blessing of the hospital, the conduct of the study always proceeded in such a manner as not to infringe on the process of training doctors to be better providers of health care. As a result, I attempted to gather as much data about the procedures and experiences of the residents as they proceeded through the simulation exercises, but strict control was not possible, thus limiting the generalizability of any results.

Initial projections for number of resident participants aspired to 40 undergoing simulation and completing surveys about their experience of anxiety and cognitive load in order to be able to use more advanced statistical analyses. In the end, data from 20 residents were collected, in addition to contextual interviews with two staff members integral to the simulation and instruction.

This research was introduced into an extant, independent program of education and training with its own curricula, strictures, schedules, and goals. In addition, not all participants had the same amount of experience, nor the same type of experience, apart from those qualities, knowledge, and skill sets foundational to basic medical education in the United States. As medical residents, the subject population for this study was, by definition, a self-selecting group, and as such may account for limits on variability in the sample.

Lack of control group

Initial expectation for number of participants was 40 residents in the Internal Medicine rotation at the teaching hospital, but as the study proceeded it gradually became clear that it would not be possible to capture a sample of that size due to time limits and availability of participants. The initial data set included only 10 individuals, and because the study occurred in an ongoing, established curricula at another institution, control over which individuals would participate in the simulation was outside the scope of this research. Eventually, I was able to capture data from 20 participants, but again, the design of the research was such that all participants would undergo the simulation, and thus no control group was available for comparison.

Small number of participants

Again, owing to time constraints and access to resources, this study only captured a limited amount of data from a small number of participants. This naturally demands caution when speculating about generalizability of any results, as well as significance of any findings. Therefore, one of the goals of this research was to focus on what the information may mean for the hosting hospital in question, including recommendations for future research relevant to the institution's interests, concerns, and ambitions.

Controversial nature of measurement of cognitive load

In the literature review I briefly mentioned challenges in measuring cognitive load. Self-report—such as I used in this study—is but one method, and remains under scrutiny by researchers for reliability. It is possible that other or future research methods will include measures from electroencephalography (EEG) or functional magnetic resonance imaging (fMRI), for example, but such technologically advanced resources were unavailable for this project. In addition, it is highly likely that there is an interaction between performance anxiety and self-reporting of results. In other words, some question remains as to how accurately and truthfully a highly anxious participant may respond to queries about anxiety.

THE STUDY

In this section I discuss the participants, procedure for data collection, and plan for data analysis I used in conducting this research.

Participants

Participants in the study constituted a convenience sample of first-year medical residents from a prominent medical school allied with a local teaching hospital in the southwestern part of the United States. The average age of the residents was 28.5 years, and 85% of the participants reported English as their native or first language. Only one resident reported no previous experience with simulations, 12 indicated having undergone between one and four exercises, four participants indicated experience with five to nine simulations, and the remaining three had undergone 10 or more simulations. Among the respondents, 15 indicated internal medicine as their anticipated field of future medical specialization, two anticipated neurology, and the remaining three projected cardiology, radiology, and hospitalist respectively.

As part of their residency training, these first year students spent a six-week rotation studying internal medicine specialization at the hospital site. During this rotation they participated in simulations developed by the faculty to highlight specific medical situations that commonly occur in the practice of internal medicine. Although occasional participation in simulation by third-year medical residents studying at the hospital does occur, ultimately no such third-year participation was captured in data collection. As mentioned previously, survey response data were ultimately collected from 20 first-year residents. In addition, contextual interviews about the simulation process and experience were conducted with two members of hospital personnel integral to the simulation education process: a registered nurse and a member of the physician faculty who participated in creating as well as supervising the specific simulation used.

MEASURES

Three instruments were used to gather quantitative data during the study. The three instruments asked participants to self-report their perceptions of the simulation on Likert-type seven-point scales.

Performance anxiety (Motivated Strategies for Learning Questionnaire)

Two of the surveys were pre- and post- variations of one another (Appendices A and B) and were based on the anxiety subscale of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1993) that has a reported Cronbach's α of .80 and is widely used in educational research of this type. The six items of the subscale were reworded slightly to make the survey more specifically relevant to the circumstances of the study. For example, the item "During assessments I think about how poorly I am doing compared with others" was adjusted to read, "During simulations or other assessments I think about how poorly I am doing compared to others." In addition, the pre-simulation performance anxiety questionnaire differed slightly from the post-simulation performance anxiety questionnaire in the temporal awareness indicated by the items. The pre-simulation performance anxiety measure asked questions anticipating an upcoming circumstance (medical simulation), while the post-simulation performance anxiety measure presented items that referred to an event that had passed. Participants rated their anxiety on 7-point Likert-type scale from “not at all true of me” to “very true of me.”

Cognitive load and fidelity

The third instrument was designed to measure the perceptions of cognitive load and fidelity of the simulation after the experience. It consisted of eight 7-point Likert-type items rated from “did not occur at all” to “occurred constantly” (Appendix C). Seven of the items were written to capture self-reported experience of the three prevailing theoretical components of cognitive load as outlined by CLT: *intrinsic load, germane load,* and *extraneous load*. For example, an item designed to capture *intrinsic load* was “Being rushed to make decisions too quickly.” An item designed to capture *germane load* was “Feeling confused about the details of the situation.” Finally, an example of an item designed to capture *extraneous load* was “Having my thinking interrupted by irrelevant distractions.” The eighth item was a single question asking simulation participants to evaluate how realistic the simulation seemed relative to any knowledge they may have had about an actual, comparable clinical experience with a real patient. This final item was rated on the 7-point Likert-type scale of “not at all realistic” to “very realistic.” This item is associated with germane load because the situation’s fidelity can easily influence the difficulty of the situation, but it may also be associated with extraneous load because a noticeably unrealistic simulation may distract from the content to be learned. This final item was rated on the 7-point Likert-type scale of “not at all realistic” to “very realistic.”

It is important to note that validity and reliability studies were not conducted for this instrument. Though generated based on Cognitive Load Theory, future research would necessarily require validity and reliability testing for this instrument in order to employ it as a research tool. Such procedure might be accomplished in a number of ways. One procedure might be to match the resident’s self-report of cognitive load from the instrument with video of the corresponding simulation exercise for that resident analyzed by an expert in cognitive load theory. Similarly, another procedure might be to allow respondents to retrospectively review video of their performance and have them identify those factors during the simulation that were distracting, for example. Triangulation of the instrument as a measure of cognitive load against other measurement tools would constitute yet another approach to establishing validity and reliability. As mentioned previously, the use of physiological measures such as an EEG or (f)MRI in comparison with the self-report of cognitive load might further bolster the development of the questionnaire instrument for future research. Finally, as Schnotz and Kürschner (2007) noted, the development of schema by learners may indicate the presence of germane load in a given circumstance, and thus another route to validity and reliability might be determining the generation of schema among residents and comparison with responses to the instrument.

An additional caution must be exercised in consideration with this instrument, as well, and that is the relationship of the respondents to the measure with regard to self-reporting. Not only does self-report risk diminished (or even absent) authenticity and accuracy about the construct in question, but also it may be that respondents are unable to correctly identify aspects of cognitive load because of lack of understanding. Knowing neither what cognitive load is, nor what comprises it, may prove challenging for participants to effectively identify when responding to the instrument. Furthermore, the presence of performance anxiety in respondents may also impact the accuracy of self-reporting. All these factors must be considered in future research related to the assessment of the cognitive load and fidelity questionnaire as a valid and reliable instrument.

The field of educational research continues to grapple with development of measures for cognitive load, employing a variety of different methods from analytical to psychophysiological (Paas et al., 2003). Furthermore, a review of some cognitive load measures suggested that "psychometrical properties of each adapted scale need to be reestablished" (Paas et al., 2003, p. 69). Given the challenges of conducting this study at a local site with technological limitations, as well as the challenge of the field in developing cognitive load measures, the approach of this study was to create an instrument based on construct validity and face validity, while acknowledging that its reliability and validity were not established.

As mentioned, residents were asked about how well they felt the simulation in question represents an authentic and recognizable clinical education experience. While data collected about simulation fidelity was not a primary focus of this study, such information does help remind researchers, hospital personnel, and students alike that questions of simulation fidelity do arise and might constitute suitable focus for future investigation. Simulation fidelity was assessed by the participants on a single item on the cognitive load instrument. Fidelity scoring is included in the analysis, but only as a point of reference offered for consideration as part of future research or curriculum design that an institution, faculty, or researchers may wish to consider.

PROCEDURE

Quantitative data collection

Held over two days during the introductory weeks of a resident's internal medicine rotation, the simulations were supervised by hospital faculty in concert with assistance and support from nursing faculty and staff. The simulations served two purposes: First, they maximized the opportunity for clinical skills training in the internal medicine discipline; second, they initiated and integrated hospital-specific knowledge about the facility—including procedures, locations, personnel, and policies—as early as possible so that residents could make the most of their time on the rotation. Thus, the emphasis of the simulation was on learning, not on formal evaluation of performance that might otherwise affect resident success in the program.

Informed consent and related protection of participant anonymity procedures

During general residency orientation (prior to participating in a simulation and any related exercises, including surveys for this study), residents were provided with a written document outlining the purpose of this research (Appendix E). Residents who signed the document acknowledged they had been informed of the reason for the research and consented to have information about their experience with the simulations recorded and analyzed. Anonymity for participants was preserved by the redaction of names and other person-specific identifying factors, or by the use of pseudonyms as necessary during reporting. The registered nurse and physician faculty member who participated in contextual interviews were also provided with a document disclosing the purpose of the research to sign (Appendix F). Signed informed consent documents were kept on file with the researcher. While the curriculum of the teaching hospital required residents to attend the medical simulation training exercises, the residents did have the option, at any time, to request that their individual survey data not be considered as part of this study without penalty or negative consequence. If any resident chose to have their survey data withdrawn, those documents would be destroyed and the information would not be included in the final analysis. The identity of those choosing not to participate would be kept confidential from the hospital faculty, and only I would know which data to exclude. As it happened, no participants requested exclusion from the study, and survey data from all 20 participants are included in the analysis. Anonymity and pseudonymity were preserved during the study and in the reporting of this document.

Simulation procedures

Each simulation took between 10 and 30 minutes. Seven primary simulations were initially available as part of the hospital curriculum. However, because the hospital established the frequency and schedule of simulations, this research only captured data from one option among the seven simulations that the hospital used. In the end, the focus simulation for this study was the atrial or ventricular fibrillation (AFIB/VFIB) case, which is a very common condition that occurs in the practice of internal medicine, involves both diagnosis and treatment, and thus an important opportunity for training new residents.

The setting

The simulation laboratories in the hospital's clinical education wing included four suites. In the AFIB/VFIB simulation, a highly technical computer-controlled mannequin was used. Prior to the start of the simulation, the suite was prepared for the procedure by hospital staff, including faculty and technical support personnel. This preparation included setting up the mannequin and the computer software necessary to run the simulation.

The simulation and data collection

When the resident arrived for the exercise, they were greeted and given a short explanation of the purposes of the survey, and then the pre-simulation performance anxiety questionnaire was administered; this typically took between 15 and 60 seconds. The survey was provided in hardcopy format for ease of administration and retrieval.

I retrieved the completed questionnaire from the resident, who then received a short briefing about the simulation from one of the faculty members who observed the scenario. This briefing included some basic information relevant to the medical issues the "patient" experienced, but the briefing also encouraged the resident to undertake the procedure or interview based on their experience and knowledge as a demonstration of what they have learned about the clinical issues encompassed by the scenario. For example, in the AFIB/VFIB case, the resident was informed of being called to the "patient's" room by a nurse with a notification about a telemetry change, but was not told the specific rhythmic change. The specifics were withheld because a central emphasis of the simulation was for the resident to diagnose the rhythm problem.

Following the initial briefing, the resident was invited to enter the simulation suite and the scenario began. The resident was expected to take the lead during the scenario and make decisions about diagnosis, treatment, and patient interaction. At least one faculty member (but sometimes two or three) observed the simulation from an observation booth and evaluated the resident's performance on a checklist assessment instrument. When the faculty felt the simulation had run its course, time was called and the simulation ended. At that time, the post-simulation anxiety questionnaire and post-simulation cognitive load questionnaire were completed by the resident; completion of these two instruments typically took a few minutes at most. Once completed, I collected the surveys, thanked the resident, and turned the session over to the faculty. Of note is that, at that point, the resident had no external validation of their actual performance while completing the final surveys. Thus, objective knowledge of performance could not affect responses to the surveys. The residents might still have had anxiety, however, because of anticipation of awaiting verdict on their performance, and they may have had other sources of anxiety such as concern about comparison with colleagues in the highly competitive medical education environment. Additional factors that might also influence anxiety among the participants included things like the ever-present concern of time and time management.

Once I returned to the observation area, the resident and faculty members conducted a post-simulation debriefing about the scenario, highlighting important aspects of the learning situation, areas of improvement, and successes. The debriefing typically lasted 5 to 15 minutes and emphasized the resident's self-reflective consideration of the scenario, dynamics, clinical procedures and technical details, and personal conduct.

Quantitative data analysis

Quantitative analysis of the surveys examined the frequency of participant responses that were self-reported across the range of possible answers. In addition, the means and standard deviations of the pre- and post-simulation performance anxiety survey responses were calculated. Then, a two-tailed repeated measures t-test was performed comparing the pre- and post-simulation performance anxiety responses. Mean and standard deviation were also calculated for the cognitive load measure, and then correlations were calculated between the pre-simulation performance anxiety, post-simulation performance anxiety, and cognitive load measures.

Contextual data collection

Two professionals were involved in the study: a physician faculty member and a registered nurse. The physician faculty member acted in a supervisory role for all 20 resident participants, and had responsibilities including introduction of the researcher to the residents, supervision of the conduct of the simulation itself, occasional participation as the voice of the "patient," and conduct of the debriefing. The physician faculty member was also one of the people who contributed to the development of simulation scenario, including components such as researching simulations and writing the case specifics.

The registered nurse acted as a confederate in the simulation exercise, supporting the resident, responding to requests for information or treatment, and prompting the resident with questions. In addition, the registered nurse was also a contributor to the development of the scenario, including contribution to the writing and review of the simulation specifically for the local hospital setting. Furthermore, the registered nurse also participated in the debriefing, offering perspectives on the exercise and case to the resident from the perspective of nursing staff. In the case of both professionals interviewed, the focus was to gather their thoughts, observations, and experiences about how the simulation was developed, intended to be used, and what actually happened when they were implemented.

Individual interviews with two members of the faculty and staff (one registered nurse, one physician faculty member) involved in the simulation exercises were conducted to collect descriptions and perceptions of the experience. Interview questions are shown in Appendix D. Each interview lasted approximately one hour and 15 minutes. Sample questions included elements such as "When did the simulation program start?" and "What do you believe you discovered about resident performance and learning in your observations of the simulation?” The questions covered a broad array of things such as the design of the simulation, conduct of the exercise, and the role of simulations in medical education specific to the local hospital as well as more generally. The purpose of this portion of the study was to explore additional data supplementary to the quantitative data through the use of interviews and observations, with an emphasis on the perceptions and experiences of the participants. Interviews were recorded in audio format and transcribed so as to preserve confidentiality. Following transcription, the digital audio files were destroyed. Interviews occurred during the course of the overall study, not after data had been collected from the 20 residents.

Contextual data analysis

Analysis of the transcripts was conducted by reading through the texts and identifying points of similarity in content between the registered nurse and physician faculty member. From that side-by-side comparison four important foci of commentary arose: general observations and descriptions of resident experience, communication elements during the simulation, issues related to standardization, and simulations in the broader context of medical education. Ultimately, the interview data helped humanize the study results and provided important information to consider for future research, as well as recommendations for faculty in the teaching hospital to evaluate for continued simulation training and curriculum development. Contextual interview data can prove useful for hospital personnel when considering not only the role of simulations, but also the larger medical education experience in the teaching hospital environment.

Chapter 4: Results

This chapter reports results of the survey administration and contextual interviews. Survey data appears in the form of histograms showing frequency of selected responses from participants with brief description of the items or noteworthy distributions. Contextual interview content appears in quotes illustrating specific points of interest or importance made by the individuals interviewed. Chapter 4 is divided into a quantitative section, Resident Experience (survey responses and statistics); and four contextual sections: Observations of the Simulation, Communication, Standardization, and Simulations in Broader Context. The Resident Experience section includes three sub-sections for the survey data. The first sub-section compares pre- and post-simulation anxiety responses, while the second sub-section shows responses pertaining to perception of cognitive load and simulation fidelity. The third sub-section discusses statistical relationships between the pre- and post-simulation anxiety measures and the cognitive load measure.

Research Questions 1 and 2: Experiences of the Resident During the Simulation: Self-Reported Perceptions of Performance Anxiety, Cognitive Load, and Fidelity.

The 20 survey items (6 pre-simulation performance anxiety, 6 post-simulation performance anxiety, 7 cognitive load theory based, and 1 fidelity of the simulation perception item) focused on the emotion of anxiety as well as the experience and perception of cognitive load, and the residents' estimation of how faithful to an actual AFIB case in a living patient did the simulation seem to be. In addition, demographic information about residents' age, previous simulation participation, prospective area of medical specialization, and native language was collected as described in Chapter 3. Descriptive analyses of the survey data were calculated and are shown in the figures below. Although some quantitative inferential statistical analysis of the survey data was conducted, the lack of a control group and small sample size of participants risks insufficient statistical power to capture significance. Therefore, although statistical calculations are reported, they should not be used to generalize to the larger populations, and instead serve only as possible point of interest for future research that would aim for larger sample participation under conditions of better research control.

Research Question 1: Levels of pre- and post-simulation performance anxiety.

First, I will examine results pertaining to the perception of performance anxiety pre- and post-simulation. Means and standard deviations of the pre- and post-simulation performance anxiety scores are shown in Table 4.1 below and are relevant to the first two subquestions under research Question 1.

	Pre-simulation performance anxiety	Post-simulation performance anxiety
Overall Mean	4.62	4.10
Overall Standard deviation	0.80	1.15

Table 4.1: Means and standard deviations of pre- and post-simulation performance anxiety (N=20)

Available histograms (Figures 4.1-4.6) depict frequency of selected values on the Likert-type scale, with side-by-side pre- and post- bars for purposes of visual comparison. Self-reports of pre- and post-simulation performance anxiety were collected from the residents prior to and immediately after undergoing the simulation exercise. The following figures illustrate those responses. In these histograms, the X-axis represents the

Likert-type range of available responses on the survey, ranging from 1 (Not At All True Of Me) to 7 (Very True Of Me). The Y-axis represents the number of participants responding at each level. The Y-axis is capped at 10 for purposes of creating histograms of the same visual ratio for easier comparison (no single item response was indicated more than 10 times). The lighter-shaded bars represent pre-simulation survey responses while the darker-shaded bars correspond to post-simulations survey responses. It is important to note that the additional question in both the pre- and post-simulation surveys used as a check of social desirability were not included in the data analyses and are not reported save to observe that the distribution of responses likely indicates that the participants were paying attention to the content of each item and responding honestly.

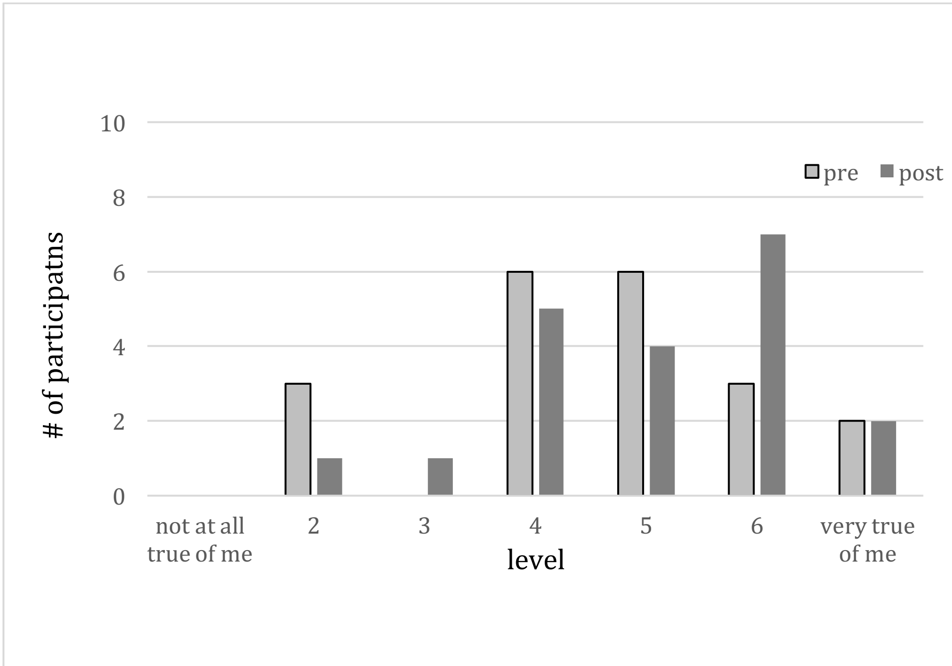

Figure 4.1. Feeling nervous about participating prior to the simulation

Item 1. I Am/Was Nervous About My Participation In This Simulation.

The first figure (Figure 4.1) shows frequency of participant self-reporting relative to the question about nervousness in participating in the simulation. Responses to Item 1 in the pre-simulation survey showed a majority clustered in the mid- to upper range, with only three respondents indicating that nervousness did not seem very true of their experience prior to the exercise. Post-simulation responses again occupy most of the mid- to upper range, with a notable increase in the number of individuals indicating the sixth level (nearing Very True Of Me), from only three participants pre-simulation to seven participants post-simulation.

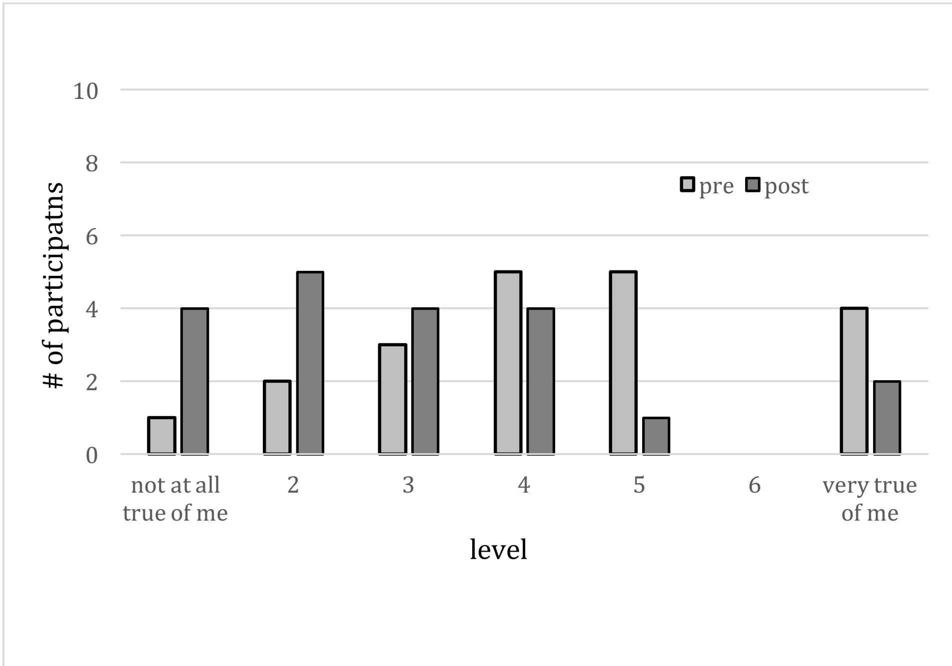

Figure 4.2. Feeling concern about comparing poorly to peers

Item 2. During Simulations I Think/Thought About How Poorly I Am/Was Doing Compared With Others.

Item 2 (Figure 4.2) asked respondents to express the extent to which they have/had concern about comparing poorly with their peers in simulation performance. Frequency of pre-simulation responses to Item 2 showed a range across the spectrum, though only one response indicated Not At All True Of Me, and no responses appeared at the sixth position before four responses marked the value of Very True Of Me. Meanwhile, overall post-simulation numbers shifted toward the lower end of the range, indicating less anxiety than before the simulation.

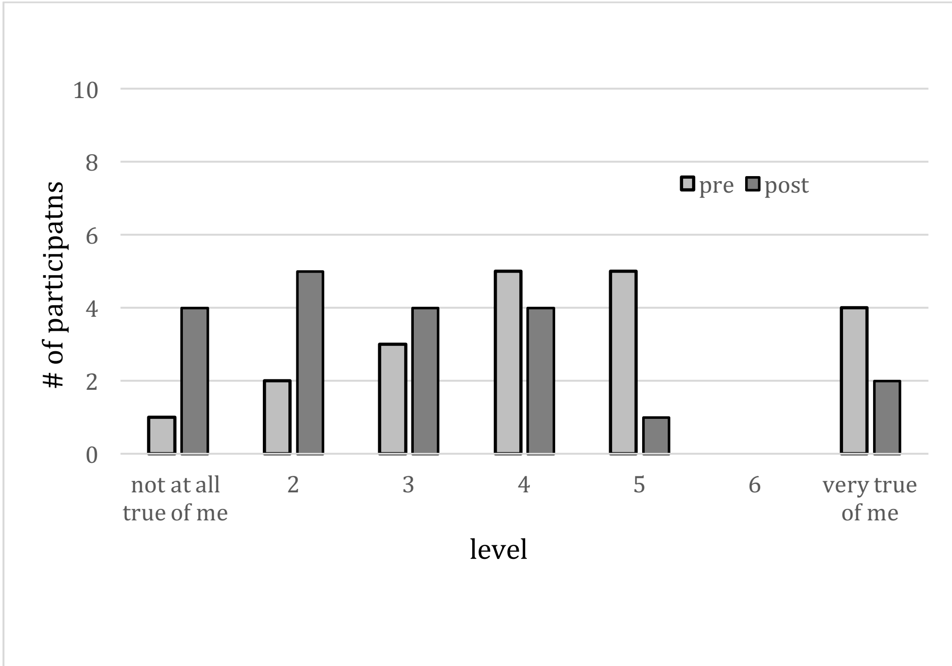

Figure 4.3. Thinking about difficult challenges during the simulation

Item 3. During Simulations I Think/Thought About Challenges With Which I Have Difficulty.

Item 3 (Figure 4.3) asked participants to reflect on things they found difficult during simulation. Item 3 pre-simulation responses showed most participants felt inclined to contemplate challenges with which they have or had difficulty during the simulation, with just one participant indicating no such inclination. Post-simulation numbers showed much the same, except that the number of responses shifted to lower levels, suggesting that challenges did not occupy respondents as much in retrospect.

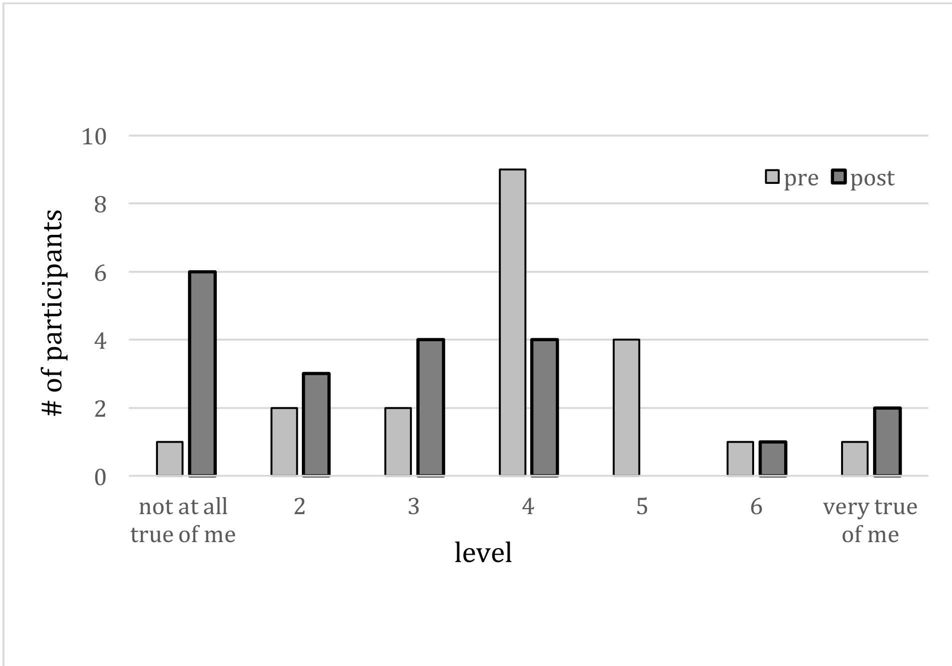

Figure 4.4 Thinking about the consequences of failure

Item 4. When I Take/Took Simulations I Think/Thought of the Consequences of Failing.

Item 4 (Figure 4.4) involves reflecting on the consequences of failure. Most pre-simulation responses to Item 4 indicated moderate applicability of the statement, with nine individuals selecting the middle response on the available scale. Only one person marked the item as Not At All True Of Me, and only one person marked the item as Very True Of Me. Post-simulation responses showed marked shift with increased numbers indicating the statement weighed more heavily as Not At All True Of Me.

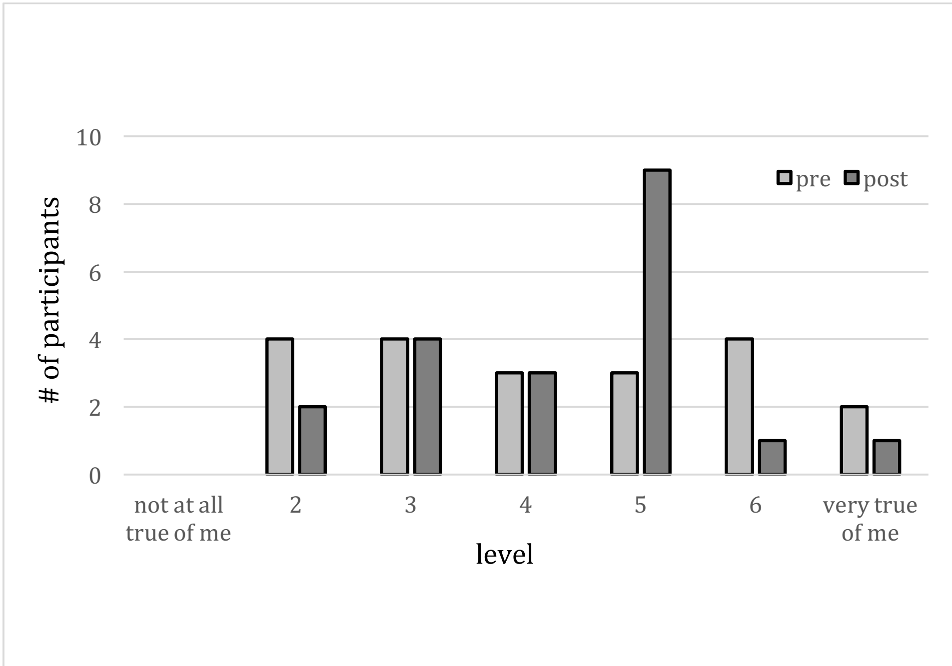

Figure 4.5. Uneasiness during simulation

Item 5. I Have/Had An Uneasy, Upset Feeling During Simulation.

Item 5 (Figure 4.5) pertains to a physiological feeling of uneasiness during simulation. The number of pre-simulation responses to Item 5 showed fairly even distribution across almost all possible choices, except no respondents selected the value of Not At All True Of Me. By contrast, post-simulation responses showed the same or reduced values for almost all levels except the fifth, which increased from three to nine recorded participants.

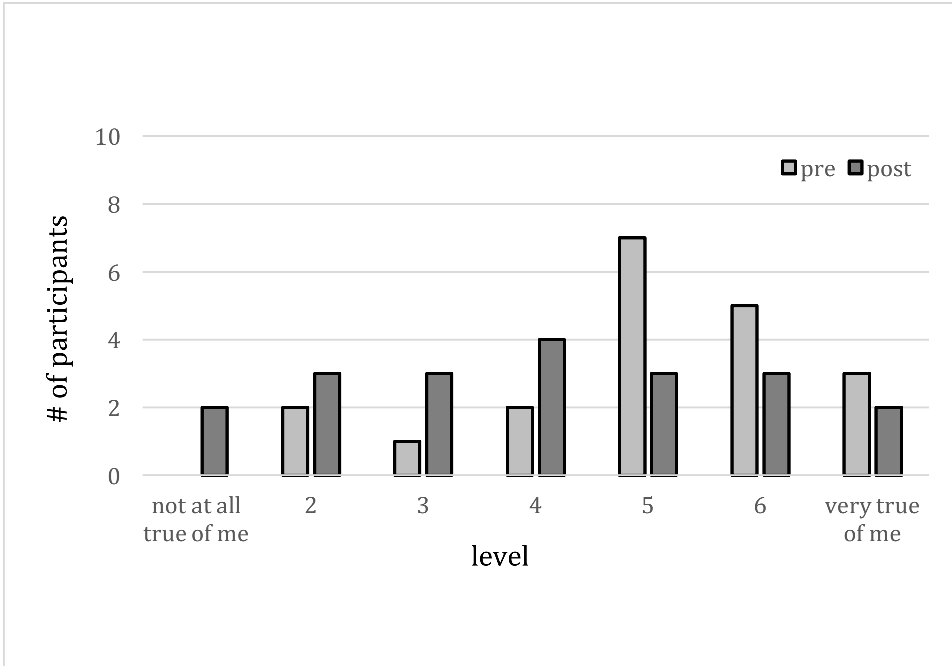

Figure 4.6. Sensation of fast heartbeat

Item 6. I Feel/Felt My Heart Beating Fast During A Simulation.

The next figure (Figure 4.6) examines the last anxiety item, which recorded awareness of another physiological experience: rapid heartbeat. As with several previous items, pre-simulation responses varied across participants, though most individuals indicated the statement moderately true—or stronger—in their experience. Post-simulation frequency shows a much more even distribution of sensation, with levels 2, 3, 5, and 6 all indicated by three participants.

In the next section, I review the results for the cognitive load and simulation fidelity survey.

RESEARCH QUESTION 1C: LEVELS OF COGNITIVE LOAD AND SIMULATION FIDELITY.

For the cognitive load survey, Table 4.2 shows the mean and standard deviation of overall level of perceived cognitive load.

Overall mean	3.24
Overall standard deviation	1.18

Table 4.2: Overall mean and standard deviation of cognitive load ratings

With regard to the individual ratings of cognitive load for each item, the histograms that follow (Figures 4.7-4.14) depict frequency of selected values on the Likert-type scale. (As there was no pre- administration of this survey, no side-by-side pre- post- comparisons appear in these figures.) All self-reports were collected from residents following the end of the simulation exercise and just before the debriefing with the attendant nurse and physician faculty member.

In the following histograms the X-axis represents the Likert-type range of available responses on the survey, ranging from 1 (Did Not Occur At All) to 7 (Occurred Constantly). The Y-axis represents the number of participant responses recorded, and is capped at 10 for purposes of sizing the histograms (no single item response was indicated more than 10 times).

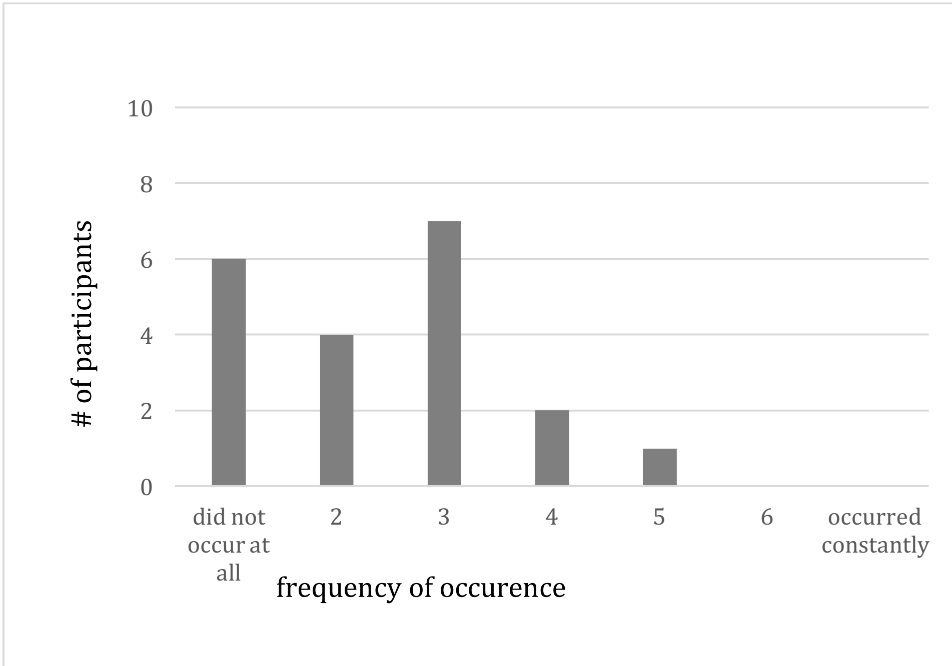

Figure 4.7. Being given too much information

Item 1. Being given too much information to track adequately.

Item 1 responses (Figure 4.7) indicated most participants did not perceive an overwhelming amount of information such that keeping track of the information proved daunting or unfeasible. Only one participant recorded a level of 5, and no one chose levels 6 or 7.

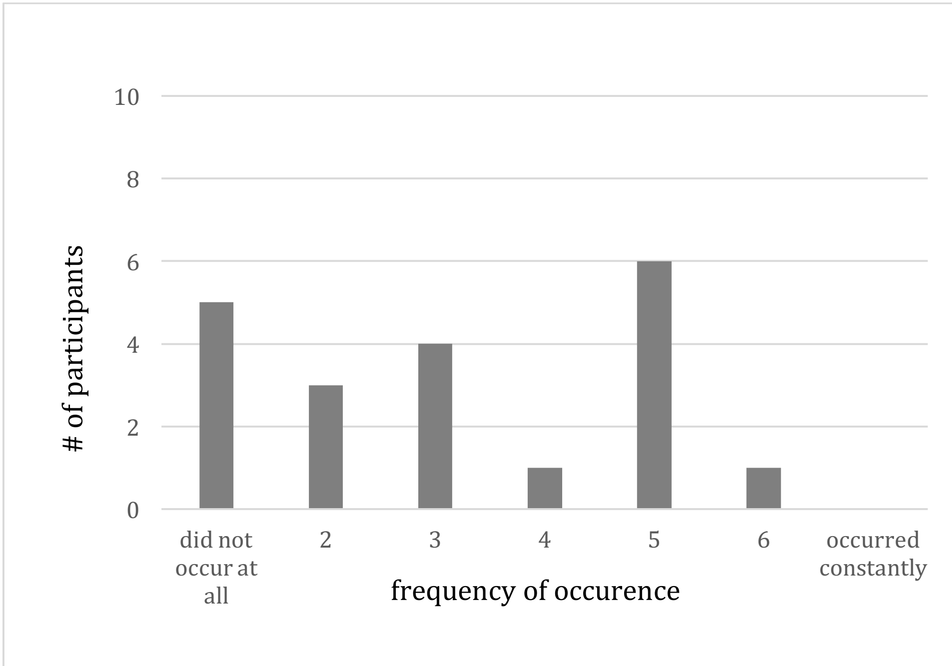

Figure 4.8. Felt rushed to make decisions too quickly

Item 2. Being rushed to make decisions too quickly.

The next figure (Figure 4.8) illustrates responses to the item about feeling rushed to make decisions. Responses to Item 2 once again indicated a range across available choices, though no participants suggested that feeling rushed to make decisions too quickly occurred at a constant rate (level 7). Of interest is the fact that only one respondent felt that being rushed to make decisions too quickly occurred at a median level. The bulk of responses fell on either side of the median, with 12 participants reporting toward the lower end of the scale (levels 1 through 3).

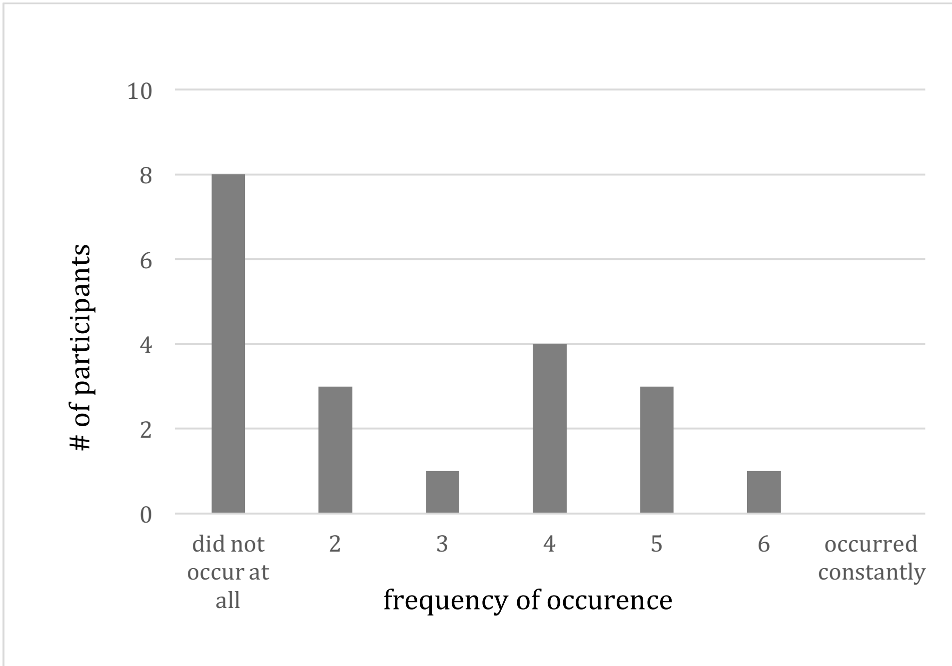

Figure 4.9. Time enough to decide relevance

Item 3. Having to take time to decide if a component of the simulation was relevant to my learning.

Item 3 (Figure 4.9) asked about having enough time to decide what was relevant to learning. The majority of respondents to Item 3 indicated that evaluating relevance of simulation content to learning did not occur at all, though seven participants did suggest that such incidence did occur somewhat based on the frequency of responses at levels 4 and 5. Once again, no participants indicated that deciding relevance occurred constantly.

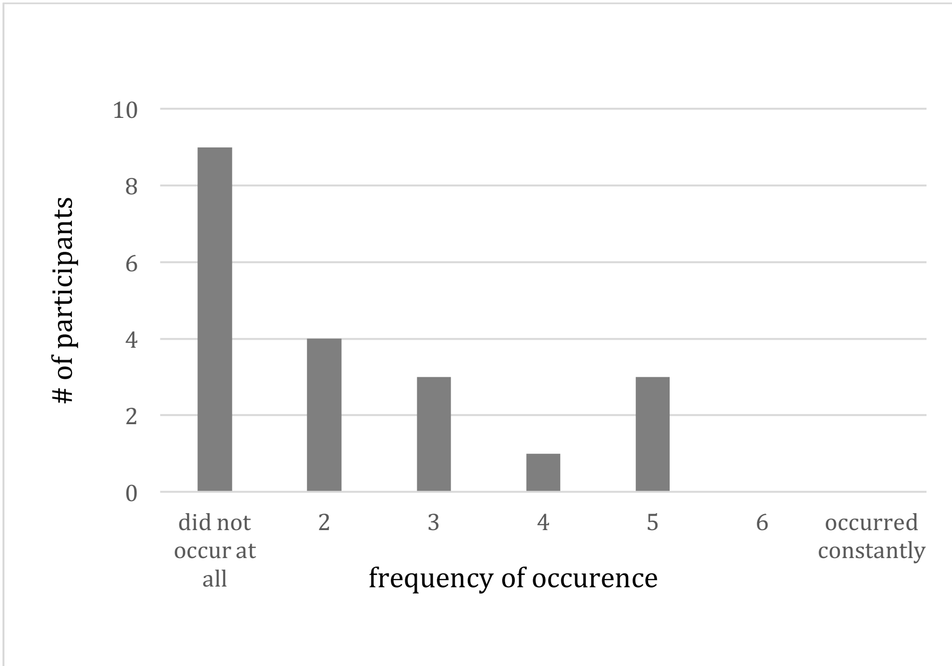

Figure 4.10. Irrelevant distractions

Item 4. Having my thinking interrupted by irrelevant distractions.

In the next item (Figure 4.10), I examined frequency of responses about irrelevant and distracting interruptions. Again, Item 4 responses eschewed the upper levels entirely with no selections of levels 6 and 7, whereas nine participants chose level 1 (Did Not Occur At All), and the rest distributed over levels 2 through 5.

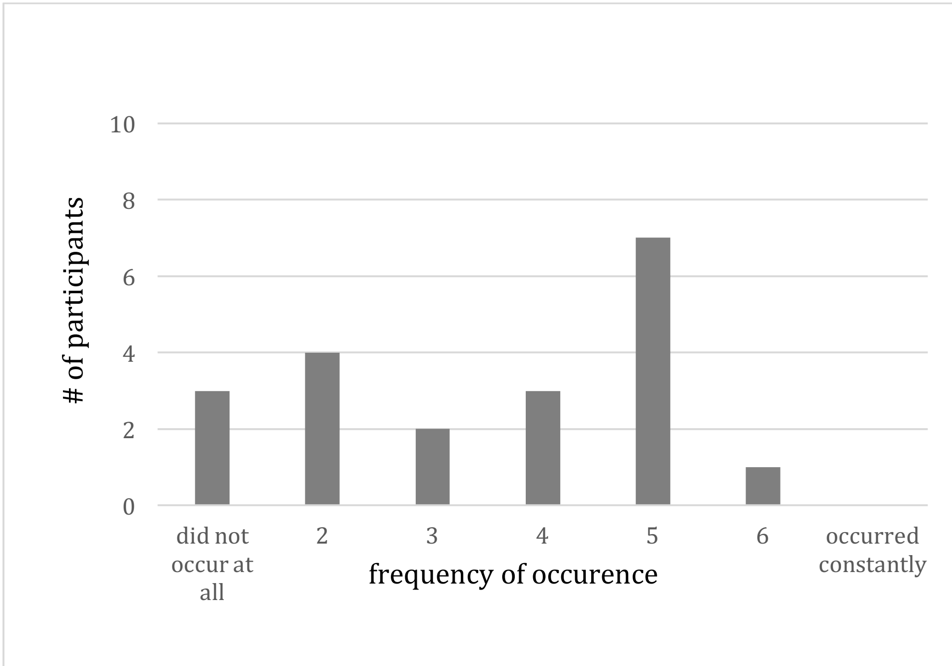

Figure 4.11. Feeling confused by details

Item 5. Feeling confused about the details of the situation.

Responses in the next figure correspond to self-report of confusion during the simulation. Item 5 frequency data (Figure 4.11) are interesting when compared to the previous cognitive load survey trends, as participants grouped on either side of the median. Eight responses fell in levels 5 and 6, whereas nine responses fell in levels 1, 2, and 3. The remaining three occurred at the median level of 4.

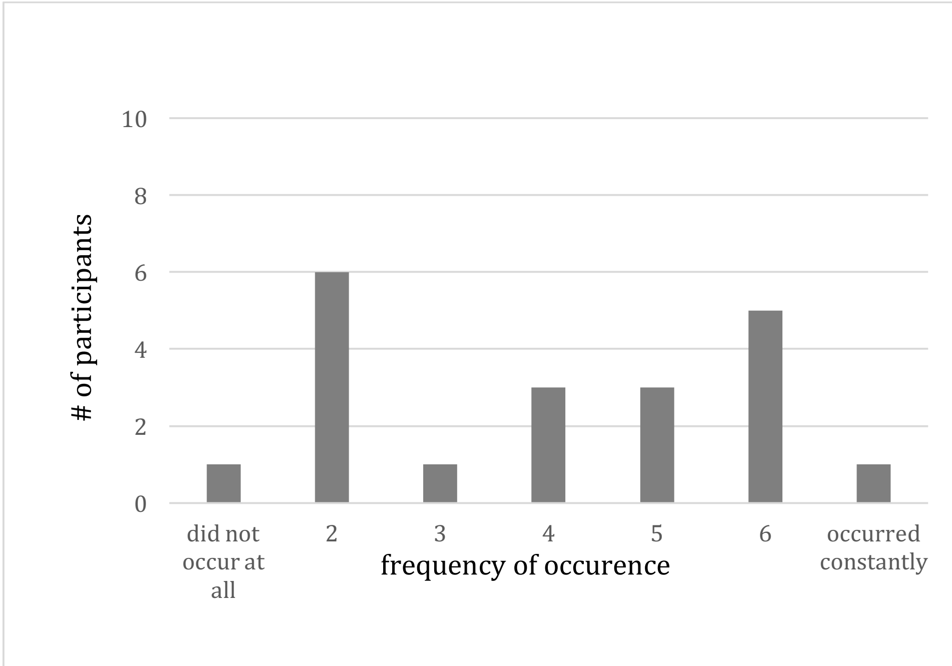

Figure 4.12. Feeling not in control of thinking

Item 6. Feeling not in control of my thinking during the situation.

Figure 4.12 shows self-report of the sensation of not being in control of one's thinking during the simulation. Another interesting distribution of self-report scores appeared in relation to Item 6 on the cognitive load and simulation fidelity questionnaire. One participant each suggested that a feeling of not being in control of one's thinking did not occur at all or occurred constantly (levels 1 and 7, respectively). The remaining respondents fell largely on either side of the median, with only three of the residents suggesting the occurrence of the subject sensation occurred moderately (level 4).

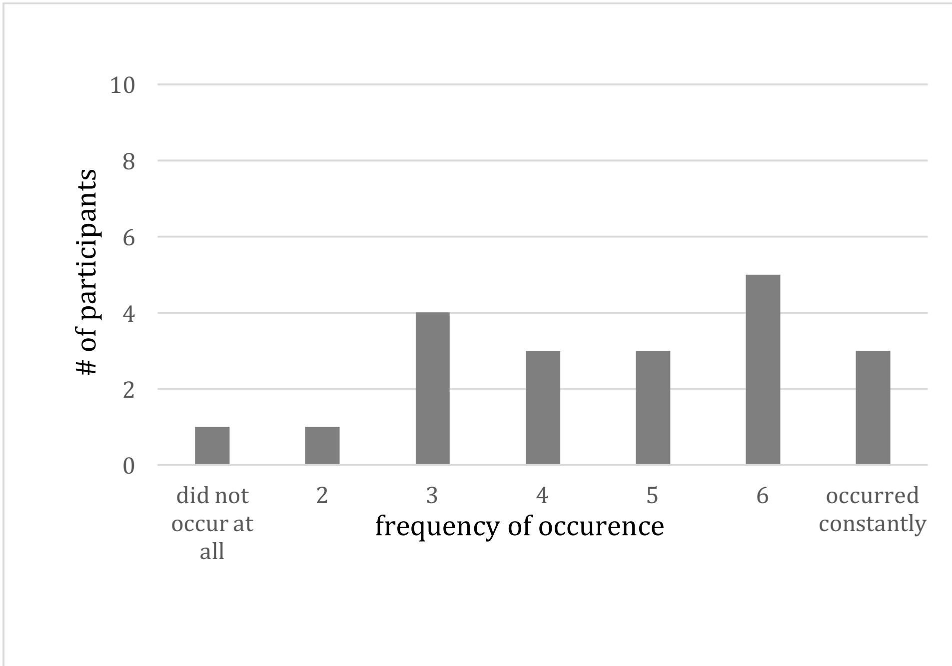

Figure 4.13. Searching for information

Item 7. Having trouble mentally searching for relevant information about the situation.

The next figure (Figure 4.13) is the final item related to the construct of cognitive load, and corresponds to the question of difficulty of mentally searching for information. Responses to Item 7 showed a broad distribution of responses across all levels, with no single level logging more than 5 commitments. Nonetheless, more participants did respond at levels 3 and higher, suggesting that—of all the questions about cognitive load—the residents in the simulation identified with the struggle of having to mentally search for information relevant to the exercise.

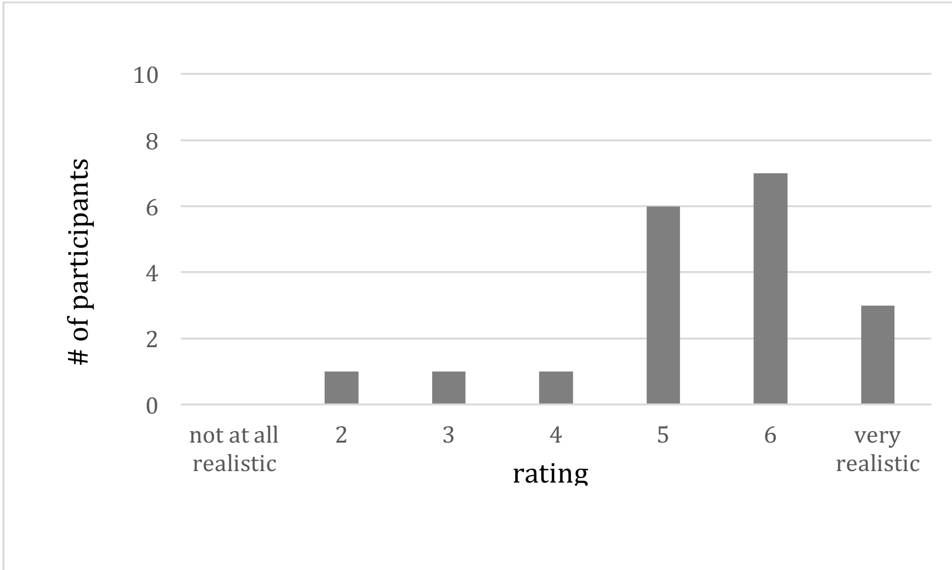

Figure 4.14. Simulation fidelity

Item 8. Please circle how realistic you felt the simulation was on the following scale.

The final figure from the cognitive load and fidelity survey (Figure 4.14) shows responses about the perceived fidelity of the simulation to an actual circumstance with a live patient. Although still reported on a Likert-type scale, the levels on the X-axis of this item differ slightly from the previous seven items. The lowest level 1 corresponds to the perception of the simulation as Not At All Realistic, whereas the highest level 7 denotes a sense of the simulation as Very Realistic. The Y-axis remains a measure of the number of respondents choosing a response. Participants overwhelmingly chose levels 5 and 6, while no responses were logged for level 1, and only one for levels 2, 3, and 4, suggesting that, overall, residents felt the simulation corresponded closely to the actual circumstance of an AFIB diagnosis and treatment with a live patient *in situ*.

In the next section I examine the means of the pre- and post-simulation performance anxiety measures, the mean of the cognitive load measure, as well as a two-tailed t-test of the performance anxiety means, and briefly discuss those results. I will also examine the correlation between the pre-simulation performance anxiety and cognitive load measures, and the post-simulation performance anxiety and cognitive load measures.

RESEARCH QUESTION 2: RELATIONS BETWEEN PERFORMANCE ANXIETY AND COGNITIVE LOAD

Research Questions 2a: Performance anxiety.

As seen earlier in Table 4.1, the pre-simulation performance anxiety measure mean was 4.62, with a standard deviation of 0.80. The post-simulation performance anxiety measure mean was 4.10, with a standard deviation of 1.15. A repeated measures two-tailed t-test resulted in a $t(19) = 2.94$, which is significant at $p < .01$, suggesting the possibility that the decrease in post-simulation performance anxiety level is worth further consideration. Calculated effect size for the change is 0.53. Although this is typically considered a large effect size, it is close enough to the line of a medium effect size that a more sensible description would be a medium effect bordering on a large effect, especially in light of the sample size limitations of this study.

Again, it is important to remember that, with a sample size numbering only 20, caution must be maintained when making assertions about statistical vs functional significance. Nevertheless, what these results allow is that future research comparisons of pre- and post-simulation reporting should be an important feature of examining the role of simulations in medical education.

Research Questions 2b and 2c: Cognitive load and its relationship to performance anxiety before and after the simulation.

The simple bivariate relations between the pre- and post-simulation performance anxiety and cognitive load measures were calculated to answer Questions 2b and 2c. The first correlation of importance is between pre- and post-simulation performance anxiety scores, and was 0.73. This high value is not particularly surprising, as it is reasonable that the relationship between anxiety prior to the simulation exercise maps highly to the perception of anxiety following the simulation. However, the value is not a perfect correlation of 1.0, suggesting that something is changing between the pre-simulation experience and the post-simulation experience. One possibility pertinent to that change may be the factor of cognitive load, although it is important to remember that other variables were not measured in this study.

Nevertheless, measures of cognitive load allow us to examine the correlation between performance anxiety (pre- and post-simulation) and begin to tease out the possibility that cognitive load represents a factor in the experience and measurement of performance anxiety. For Question 2b, the correlation between pre-simulation performance anxiety and cognitive load was 0.04, almost nonexistent. Such a value is reasonable considering the experience of pre-simulation performance anxiety is temporally removed from the perception of cognitive load factors because the simulation—in which the components of cognitive load are expressed and experienced—had not yet occurred. However, for Question 2c, the correlation between post-simulation performance anxiety and cognitive load was 0.42, a moderate correlation of interest. Such a value raises the possibility that cognitive load has some kind of relationship to the perception of anxiety following the simulation, even though it did not map highly. The relationship of cognitive load and post-simulation performance anxiety would also constitute a worthy focus of future research.

Other potential factors.

In addition to regressions on demographic data, future research might examine factors like the measurement of fidelity of the simulation. Although a self-report assessment of fidelity was collected from the study participants, a regression analysis was not undertaken because of the small sample size and the fact that fidelity was measured with only one item. Other elements worth examining in future performance anxiety and cognitive load research in simulation-based education include consistency of implementation of the simulation itself, and whether or not academic performance on the simulation was being formally evaluated. Again, these factors lend themselves to consideration for future study, and go beyond the scope of the present project.

In the next section, we present the contextual observations and experiences of the residents undergoing the simulation as captured in observation of the learning sessions and interviews with a registered nurse and physician faculty member present and integral to the simulation experience.

RESEARCH QUESTION 3: OBSERVATIONS OF THE SIMULATION EXPERIENCE AS DESCRIBED BY THE RESIDENTS, NURSES, PHYSICIANS, AND RESEARCHER.

In the next sections, I report on four themes that emerged in analyzing the contextual data, beginning with the role of novelty in participants' experience of the simulation, issues and qualities of communication with regard to simulation training, standardization, and culminating in the role of simulation in the broader context of medical education.

The role of novelty of simulations.

One of the central experiences for residents undergoing the atrial fibrillation simulation is encountering the novelty of the exercise. Despite the increasing presence of simulation as an instructional tool in medical education, one resident indicated the AFIB exercise represented a first experience in simulation. By contrast, 12 respondents reported experience with between one and four simulations prior to this research, and seven residents indicated experience with more than five simulation experiences. The question of previous simulation experience was not limited to the specific hospital setting in which this research took place, but rather encompassed any simulation the resident chose to indicate as part of medical education. Thus, some of the responses about previous simulation experience may have included those from medical school, experiences in other medical education settings, or perhaps even circumstances such as independent private study or undergraduate pre-medical education.

Another facet of the resident experience in the simulation includes not only the relative novelty of the simulation itself, but also the content central to the learning objectives desired by the hospital. Participation in the simulation did not require previous, extensive knowledge of AFIB diagnosis and treatment. Although the simulation presumed basic familiarity with AFIB, residents were expected to participate regardless of whether they could immediately and accurately summon circumstantial specifics to mind. In interview, Gabrielle (pseudonym) described the following: “So, they are so new at this, they are counting on that RN (registered nurse) to know the correct dose” (Contextual Interview Transcript Nurse, p. 14). Observations of some of the simulations also noted that although sometimes a resident might, for example, know the type of medication to prescribe, they did not always know the accurate dosage (Researcher Observation Notes, p. 1). Furthermore, Gabrielle went on to indicate that such lack of content knowledge could prove vexing or disconcerting for the resident in question:

> “Because the RNs were coached that if an improper order was given they were to say: ‘What is your dose order, doctor?’ In other words, not to say: ‘I’ll give 5 milligrams, doctor.’ If [the resident] said: ‘Give Cardizem,’ ‘What is your dose, doctor?’ Ok? And several of [the residents] got very frustrated by this” (Contextual Interview Transcript Nurse, p. 14).

Responses to such circumstance, however, included more than just frustration. Sometimes, residents would seek additional resources as an aid to knowledge, and sometimes residents would demonstrate a moment of self-awareness or self-analysis about their own lack of content. According to Gabrielle:

> "They first got frustrated, or they reached in their pocket because they said, 'I don't know the exact dose,' and they pulled out their book from their pocket, and some of 'em looked back up, and some of 'em honestly looked up at the ceiling, took a big sigh and said, 'I really need to know this.' In other words, they recognized their own lack of knowledge" (Contextual Interview Transcript Nurse, p. 14).

Thus, one of the experiences of residents in the simulation was an encounter with the limits of their own knowledge, and the subsequent emotions that such realization may engender, including frustration, uncertainty, or a moment of self-reflection. This moment of self-reflection appears important, what Gabrielle called "a big learn" (Contextual Interview Transcript Nurse, p. 15).

Communication before, during, and after the simulation.

The next consideration in the use of simulation as a teaching and assessment tool in the hospital setting is the varieties, instances, and role of communication. This section reports on communication before, during, and after the simulation, and includes examples from the residents (students), the physician-faculty members, and the staff (nurses) involved in the simulation exercise. The basic structure of the simulation exercise places the various examples of communication into several sections. Listed in order of occurrence, these sections are: preparation, pre-briefing, the exercise proper, debriefing, and transition. In the event that specific communication instances qualify for—or occur across—multiple sections, those examples will be noted as such, with commentary about why, or special notification as to the nature of those examples that qualifies inclusion in multiple divisions.

Communication during preparation.

The preparation portion of the simulation occurs first. This is the period when the room is being set up to accommodate the exercise and the personnel involved. During this time, the mannequin is configured in a hospital bed as a patient typically would be, and the relevant software that controls the mannequin is started. This software allows the physician faculty to program and change aspects of the "patient's" condition, including such elements as heart rate, blood pressure, and oxygen saturation. In addition, the bedside monitor that will provide residents with vital statistics is activated, and connection to the software is established. Finally, a printed hardcopy of an initial EKG (electro cardiogram) is placed on a nearby table for the resident's reference during the exercise.

The preparation phase is also the time when the physician faculty goes over the basic exercise template with the nurse confederate who assists during the simulation task. The physician faculty explains that the nurse's role is to assist the resident with such things as administering medications via intravenous line, answering questions the resident may have about the patient's condition or vital statistics, and prompting the resident with questions about treatment or procedures in order to help move the exercise toward conclusion. Preparation also includes encouragement to the nurse confederate to avoid giving away too much explicit exposition of the medical condition—or its proper treatment—thereby placing the burden of diagnosis and proscription on the resident. Although the student undergoing the simulation may request help from the nurse, and such assistance may be readily given, the intent of the exercise is encouraging the students to undertake such request of their own initiative, rather than adopting a more passive role. The transcript interview with a member of the nursing staff illustrates an example of the kind of communication that occurs during the preparation phase:

> "And the good news is that the RN (registered nurse) is coached not to help the physician by simply giving him or her the answer, ok? So, it's important that the confederate—which in this case is the registered nurse—is informed that they should not simply say, 'This is what the change in the rhythm is, doctor. Make the decision.' Ok?" (Contextual Interview Transcript Nurse, p. 4-5)

The preparation stage also includes examples of informal communication that are not about simulation instruction or operation per se, but rather to reinforce the active attention of the various personnel to task progression. For example, just prior to the start of the next stage—the pre-briefing—the physician faculty may ask the nurse, "Ready? Everyone ready? Ok." This kind of communication serves to alert the individuals in the room of the impending start of the simulation exercise. Focus on task moves to the forefront of everyone's attention.

As a final note, the preparation stage typically occurs only once at the start of the simulation day, and usually does not require repetition as the same mannequin, computer software, and instructions remain in place for the subsequent residents scheduled to undergo simulation training at that event. Typically, the only "re-preparation" that might occur would be something like replacing the paper EKG printout on the table for the next resident.

Communication during the pre-briefing.

The pre-briefing stage takes place immediately following the preparation stage. This is the phase in which the physician faculty leaves the training room and meets with the resident participant waiting in the hallway outside. The nurse confederate and the principal investigator remain in the simulation room, awaiting the return of the physician faculty that signals commencement of the simulation exercise proper. During the pre-briefing phase, the physician goes over some basic instructions with the resident, the most central of which is to treat the simulation as an actual visitation with a living, breathing patient. The resident receives a small paragraph in writing that describes the scenario in which the nurse has noticed a change in the rhythm of the patient's heart and has called the resident in accordance with standard procedure in such an event. Thus, an example of the kind of communication that takes place during the pre-briefing is not just verbal instruction relayed from physician faculty to resident, but also the written component with additional information on the patient and the scenario. The pre-briefing typically consumes no more than five minutes of overall time, and the final verbal instruction to the resident is usually, "Wait two minutes and then come in." In all observed sessions, communication did not occur between the nurse and me (the two individuals remaining in the room) observing the simulation for purposes of this study.

Communication during the simulation proper.

Next, the physician faculty returns from the hall and takes up the control position behind the observation window at the computer. The nurse confederate remains bedside. After a short period, the resident knocks and enters the suite. At this point, the simulation is underway, and the resident is expected to conduct a diagnosis and treatment plan for the patient relative to the interaction and communication that occurs. In some cases, the resident makes an introduction of himself or herself to the patient. In other instances, the resident opens communication by consulting with the nurse before speaking to the patient (Researcher Observations, p. 3, 5). Sometimes technical issues plagued the conduct of the simulation, such as failure of the wireless information system to convey simulation data from the computer software to the in-room monitor (Researcher Observations, pp. 1-8).

During these moments of technical difficulty, I was able to notice, on occasion, the potential impact on the resident. For example, there were moments when a resident's immersion in the scenario seemed momentarily suspended, or at least disrupted, thus suggesting that an issue like technical difficulties might impact simulation fidelity (Researcher Observations, p. 7).

During the course of the simulation, the resident undertakes tasks such as a physical examination, direct questions to the patient about sensations, symptoms, and medical history, and consultation of the information on the monitor as well as the printed EKG. From a position behind the screen the physician faculty acts as the patient's "voice," answering questions or offering patient comments out loud to contribute to the course of the exercise.

Resident interaction with the patient and the nurse constituted the most significant components of the exercise proper, and also the communication that I observed. Although there were common elements to all of the residents' approaches (e.g. asking if the patient felt short of breath), the quality of the overall communication differed across participants. As the nurse noted in interview, "I noticed what seemed to get them— the—the first delay, is that they— they are not certain what kind of a conversation they can have with the patient. Is the patient giving them the best information they— that they could give them?" (Contextual Interview Transcript Nurse, p. 6) The physician faculty observed something similar:

> ". . . even if I had told a resident that I was going to be the voice for the simulaid, that I was going to be in the room but to go ahead and ignore me—I sometimes felt like if they got to a point where they weren't exactly sure what to do next they might look back over at me for guidance." (Contextual Interview Transcript Physician, p. 7)

These kinds of uncertainties or "bumps" in the course of communication prompted reflection about the communication overall. For example, might some miscues or lack of commitment to the integrity of the simulation be minimized by better instruction of the resident during the pre-briefing stage?

A prominent event seen during the exercise occurred at the moment the residents requested administration of a medicine in response to the onset of rapid increase in heart rate. Frequently, residents would know the specific type of medicine to give, but not know the recommended dosage. As a physician faculty observed, "I would notice that sometimes they might look back for guidance, like, 'Ok, do I keep going?' 'Is it ok if I didn't know the dose of that drug?' Um, that sort of thing" (Contextual Interview Transcript Physician, p. 7). This was further reflected when residents displayed lack of confidence or understanding with regard to communicating with the nurse in the room. The nursing staff interviewed suggested such hesitancies owed in part to experience. "The new ones did not know what the registered nurse could do to help with information. The ones that were further along definitely engaged the knowledge and skill of the registered nurse" (Contextual Interview Transcript Nurse, p. 11).

It is important to note, however, that knowledge gaps and uncertainties about limits or protocols of communication are considered part of the simulation exercise and the evaluation that physician faculty made of a given resident. "Because we wanted to see kind of what they would do on their own, not if we were back there kind of encouraging them to continue, that sort of thing" (Contextual Interview Transcript Physician, p. 7).

Additional aspects of communication include linguistic exclusivity and jargon, especially with regard to patients. For example, Gabrielle reported that:

> "individuals need to have some mentoring as far as how they approach a patient and talk to them about their symptoms. Uh, medical-speak versus patient-speak.

> Uh, I've gone so far as in the debriefing to say, 'You know, I noticed you used 'encyclopedia' instead of 'reference book,' ok? Do you think your patient can relate to the word 'encyclopedia' or 'reference book?' You know?" (Contextual Interview Transcript Nurse, p. 12)

Perhaps no better illustration of the critical role effective and complete communication played in the simulation exercise—and by extension, practice with living patients—lay in the comment made by Gabrielle regarding instructions issued by residents during the treatment of the arrhythmia:

> ". . . when a physician tells me: 'Give Cardizem for this patient,' that is an incomplete order, ok? The order must be: 'Give Cardizem, five milligrams, I.V. push, stat.' That is a complete order, ok? So, if I went over and I drew out a syringe five milligrams—which I happen to know is the correct dose—and give it, I would be practicing medicine without a license" (Contextual Interview Transcript Nurse, p. 14)

Communication during debriefing.

A concern reported regarding communication during the debriefing portion of the exercise was a lack of consistency among the physician faculty members who oversaw and conducted the post-simulation debriefing with the resident:

> "—I think the doctors that are running it—the faculty—are wanting— they understand it's important but they're not being as formal in the process as they should be. There should be a determined set of questions, everybody should get the set of questions, there's too much variability from one student to the next" (Contextual Interview Transcript Nurse, p. 17)

A similar sentiment expressed by a physician faculty member during interview touched on the issue of consistency in debriefing approach, but appended some additional perspective about standardization for the simulation as a whole. "I think it's interesting because I think everyone kind of has different opinions of the simulations and I don't think we've necessarily standardized the staff training for the simulation" (Contextual Interview Transcript Physician, p. 13).

A noteworthy complication to this perspective, however, also came from the physician faculty who expressed a recognition of the complexity of standardization in an exercise like simulation training. This complexity extended not just to the nature of the simulation itself, but also the individual approaches to running the simulation:

> ". . . some of the staff just enjoy, kind of, working with the residents and are a little bit more flexible. For example, if there are technical issues that come up during the simulation they're able to, kind of, work around it, and just really kind of focus on that learning interaction with the resident, whether or not it's going to be the same with the next resident, say, when the technical issue gets fixed. But some people are a little bit more— I think it stresses them out a bit more if it's not running, kind of, exactly the same, kind of, each time . . ." (Contextual Interview Transcript Physician, p. 13)

A goal of the debriefing phase was to help clarify issues or content knowledge gaps the resident may have experienced during the simulation. The kinds of communication necessary to address such aspects included prompting the resident to read up on the topic that had been encountered during the exercise:

> ". . . especially if a resident missed some things during the simulation, during the feedback session we would put in, you know, some recommendations, some advice: 'Now when you go and read about this particular topic tonight you're going to remember it' the next time they see a patient with that, and that I think was a key focus for some of our cases, was we didn't' expect them to know everything that was being thrown at them in the case. We only wanted to give them a relatively real example of what they are going to have to know the next time they see that particular situation" (Contextual Interview Transcript Physician, p. 11)

In other words, critical to communication during the debriefing stage was the clarification of missed or unclear content knowledge or procedure, but also the impulse to reflect upon the exercise itself and how it had revealed knowledge gaps, thus promoting cognitive attention to change or improve understanding.

Communication during transition.

The transition portion of the simulation was simply a period of time during which the resident who had just completed the exercise departed, and the relevant staff reset the simulation components (including the mannequin, the computer software, and any other relevant tools in the room) in preparation for the next resident. During this time, communication tended to occur exclusively between the physician faculty member and the attendant registered nurse. Such discussion might simply be anticipating the next participant with comments like, "Are we ready for the next one?" At other times, the discussion between registered nurse and physician faculty might have been about refining the conduct of the exercise, including reminders not to prompt the resident too much with solutions to the medical quandary or proper procedure. Other possibilities for communication occurred when either the physician faculty or the nurse would consult for confirmation of an observed behavior or condition during the simulation that just finished.

The examples of communication provide a springboard to examine the data regarding standardization, discussed in the next section.

Standardization.

During reflection about the simulation experience, the physician faculty elucidated some perspectives on standardization as an aspect of simulation education, noting the challenge to achieve standardization in a medium-sized teaching hospital context: ". . . there are some inconsistencies in the standardization how— I would say the, um, of how the simulation is run based on some of the technical differences between the rooms, maybe" (Contextual Interview Transcript Physician, p. 5).

Variations from the standard due to technology and equipment.

These challenges can take a variety of forms. The "technical differences" mentioned referred to aspects such as availability of computers and software necessary to fully integrate the vital statistics monitors and mannequin during a given instance. Sometimes the software ceased working temporarily ("crashed") and required restarting, or sometimes a larger hospital system such as the digital wireless network allowing data transmission might experience a problem. Even the geography of the different rooms used for the simulations played a factor in different experiences of the simulation. As the physician faculty reported:

> "So one room might have, uh, the faculty behind, um— running the computer behind kind of a glass wall, and then another room, um, might be a little bit different layout so the computer's kind of out in the open and they can see the faculty kind of running the computer which theoretically, um, may not make that much difference— I don't really know, actually . . ." (Contextual Interview Transcript Physician, p. 5)

Variations from the standard due to limits on resources.

Limitations on resources and formalized processes also challenge the consistency of simulation presentation:

> "I bring that up with the technical aspect because it's kind of been a sort of trial-and-error sort of process, I think, for some of us. Now some of us have gone towards, uh, to formal training like, um . . . like Dr. Velez (pseudonym) has gone to, um, Harvard— they have a simulation program there, and he's— he's brought back some of the things, um, and I had some discussions with him about some of the things he's learned there, so he's been a mentor in that, in that aspect." (Contextual Interview Transcript Physician, p. 4)

Variations from the standard due to differences in the case production.

The presence of published cases for simulation suggests a certain degree of standardization is possible.

> “[T]he writing portion is probably the most difficult in that we have to, uh, come up with a case, and usually we have some kind of learning objectives in mind, and we— we will, uh, look to see if there’s a similar case out there, ‘cause actually some— there’s a number of, um, sim cases that are now published, and so there’s like a repository for these things now.” (Contextual Interview Transcript Physician, p. 2)

However, simply transposing a published case to the specific teaching hospital location is not a straightforward process. Adjustments to case details or presentation must be made to accommodate not just locale, but also differences in content focus or learning objectives. As the physician faculty member stated,

> “when I was helping write the chest pain case that’s where we looked to see if there’s anything out there already. Um, sometimes there’s something similar and we’ll kind of modify that, or, um, I think the initial cases were really written from scratch. Um, the writing part’s tricky ‘cause you have to go through it and then we— we have to, like, edit it, and then we’ll usually, um, try it out, but then there may be a revision period where we have to, um, go back through and then I’ll get feedback from the other sim faculty and also from the program directors to see if it’s meeting, like, um the learning objectives.” (Contextual Interview Transcript Physician, p. 3)

The need to modify existing content for a specific locale or goal suggests that standardization has limitations at broader levels. Consistency in a training tool may be limited to high level aspects such as the medical condition the tool is used to diagnose.

Variations from the standard due to their use for teaching residents.

At another level, the issue of standardization arises in the instance-to-instance deployment of the simulation for teaching residents in the hospital setting. This is the point at which the conflict of perspectives on the extent to which standardization should take place, and how it should be applied, occurs. The physician faculty asked the question, “is every resident getting essentially the same experience?” (Contextual Interview Transcript Physician, p. 5). Discussing the challenges in simulation standardization (or the lack of such standardization), the registered nurse posed a similar query: "I coached the faculty when they were conducting their simulations about keeping the consistency from one learner to the next is— is so important to collect the science that is not all over the place, you know" (Contextual Interview Transcript Nurse, p. 2). The AFIB simulation itself has an aspect to it that is standard, as the nurse indicated:

> "this is a standard, classic situation that every internal medicine resident is going to encounter very frequently in their residency, ok? This is a common situation that addresses a lot of competencies, not just the recognition of the abnormal EKG, but how to approach a patient who you're unfamiliar with, how to gather information from not only the patient but the registered nurse and the chart, ok?" (Contextual Interview Transcript Nurse, p. 4)

One can contrast the regularity of the AFIB condition in the medical experience with the commentary about the presentation of an exercise in that regularity:

> "there seemed to be a lot of shifting of what were supposed to be simulated chart documents . . . I think that that was not handled the same way every single simulation, and that could be part of a bias in the outcome by the learner that they were not presented the chart in a manner that they were used to viewing it." (Contextual Interview Transcript Nurse, p. 6)

Variations from the standard due to presence or participation of others.

Furthermore, the presence of the nurse confederate introduced another variable affecting consistency of presentation. Not only might the physician faculty vary their approach to overseeing and conducting the exercise, but the nurse might give different information, or perhaps more or less help, from episode to episode: "anything else that the registered nurse said was highly variable based on what the resident asked [the nurse]" (Contextual Interview Transcript Nurse, p. 6).

In the next section, commentary from the faculty and staff present during the simulation exercise pointed to the presence, role, and experience of simulation as a component in the broader medical education context.

Simulation in a Broader Context.

In this section, commentary from the faculty and staff present during the simulation exercise pointed to the presence, role, and experiences of simulation as a component of the broader medical education context. Some of what participants told me during the contextual interview concerned the function, feature, and status of simulation in the larger medical education arena. To set a time reference, a registered nurse involved in developing and conducting the simulations for training purposes reported that simulations at the local teaching hospital began "August 2007" (Contextual Interview Transcript Nurse, p. 1), but quickly added that "there were several of us that had been doing simulations prior to that but the sites were out in the various hospitals" (Contextual Interview Transcript Nurse, p. 1). This same individual had "been involved in clinical education, literally since 1995" and has a "background" as a "masters-[degree]-prepared registered nurse, and that my specialization is education, in particular my practicum was simulation training" (Contextual Interview Transcript Nurse, p. 1). Thus, the role this particular individual undertook in the simulation education portion of the resident training program in internal medicine at the teaching hospital reflected some previous experience and education. Further, the intent of the hospital to capitalize on the registered nurse's previous experience reflects the establishment of the teaching hospital as a participant in the larger move by the medical education community to continue incorporating simulation training as part of the resident education experience.

This same individual was further involved in the development of the learning objectives for the training sessions:

> "In those cases there were specific learning objectives that we—[a physician faculty member] and I—worked together to identify, that the residents had to, uh, portray—whether it was that they actually, physically were examining the patient and making decisions and calling out orders, or whether they simply discussed

> with the nurse or the other, uh, clinical personnel." (Contextual Interview Transcript Nurse, p. 2)

This commentary recognized that employment of simulation training intended to serve in an educational capacity as an additional component of resident training within the hospital. Further, the simulation also provided a means of assessment of skill and knowledge by which the physician faculty members could evaluate the residents with regard to certain commonly encountered medical scenarios.

> "The second process that I did was, I worked with Dr. Velez to build his objective assessment grids so that they would be objective and measurable and less subjective. So that way they could distinguish the performance of the residents in particular to those two scenarios." (Contextual Interview Transcript Physician, p. 2)

Gabrielle went on to elucidate further the role she played in developing the simulation training program:

> "I worked with him as well as other faculty on pre-briefing before a simulation and debriefing after the simulation, and the training that I use with them is all vetted by various simulation leaders in the world . . . the Society for Simulation in Healthcare, on particularly what must be covered on the pre-briefing." (Contextual Interview Transcript Nurse, p. 2)

Making reference to a professional organization that works to establish standards for pre-briefing techniques, for example, reinforces the role of the simulation training in the teaching hospital as a localized example of an educational component more broadly recognized and utilized throughout medical education.

Time, and the challenges associated with managing it effectively, play a prominent part in the experience of medical education, and in the practice of medicine itself. Consider the challenge to the learning cycle expressed in the following:

> "I would say the— the element that is most common is that the pre-brief[ing] is not long enough, because either individuals have come in late, you know they were scheduled for one o'clock [1300 hours]—they didn't show up until one-ten

> [1310 hours]—and faculty is trying to keep on a schedule, ok?" (Contextual Interview Transcript Nurse, p. 3)

The difficulty of keeping the efficiency of a scheduled educational environment within the context of the practice of medicine not only presents a challenge, but also reflects the larger struggle within the professions of both medicine and education to navigate necessary discharge of duties, aspiration to goals, and the vagaries of circumstance that all require—and deplete or impinge upon—that most precious medical resource: time. Indeed, the registered nurse explicitly stated as much: "So that's a big impediment everywhere, it's not just unique to this exercise, ok? So, even if the individual is running late you cannot skip pre-briefing because the performance is significantly impacted" (Contextual Interview Transcript Nurse, p. 3). Important enough to warrant clever adjustments in scheduling, time became a focus of manipulation in order to ensure the integrity of the exercise: "after the first couple of times this happened, instead of planning to start at one o'clock, we planned to start at one-fifteen, even though we told everybody to get there at one, ok?" (Contextual Interview Transcript Nurse. p. 7).

Another aspect suggesting the contribution this simulation in this setting makes relative to the larger body of simulations, education, and medical practice, is the recognition that the AFIB scenario represents a very common experience in the life of the internal medicine practitioner. As noted in a previous section, "This is a common situation that addresses a lot of competencies" (Contextual Interview Transcript Nurse, p. 4), and the knowledge gleaned from the exercise represents the kind of content and procedures in use to deal with "Daily occurrence" (Contextual Interview Transcript Nurse, p. 5). Thus, part of the impetus behind simulation training is to reflect a kind of normality, and to cultivate a normality of response in order to address that normality of occurrence in a safe, healthy, accurate, and complete manner. During interview, the physician faculty member expressed much the same sentiment, saying, "I think it really exposes them— we always try to pick simulations that represent experiences that they will encounter" (Contextual Interview Transcript Physician, p. 6).

Simulation training also occurs at the undergraduate or medical school level, further reflecting the larger place simulation has as an increasingly employed teaching method. "Ok, so there were individuals who did remark to me, personally, that in their undergraduate or their medical school training, that they had done simulation" (Contextual Interview Transcript Nurse, p. 8). Compare this statement with data collected from the surveys in which 95% of respondents reported one or more previous experiences with simulation training. A local teaching hospital's decision to engage simulation as an educational component of residency reflects increasing trends in medical education to employ simulation exercises and materials as a supplement to the process. That said, not all residents had previous simulation training, so while its use may be increasing, simulations may not yet constitute a condition of such regularity as to be an expected condition of prior experience by the time an individual arrives at the hospital to begin a residency. In reference to residents with moderate levels of experience, Gabrielle observed: "The middle of the road people hadn't really been exposed to simulation but had not formulated a mental aversion to it, so they were simply told that they were going to have an exercise. They didn't really . . . understand what that meant" (Contextual Interview Transcript Nurse, p. 8).

An important observation relative to prevalence of simulation training in a broader context necessarily examines the experience of students and residents entering programs from educational and socio-cultural backgrounds outside the United States. As the registered nurse observed, not all doctors going into the residency program transitioned with ease into simulation training:

> "more likely individuals of non-, uh, American background, ok . . . because the language barrier—they had not seen the technology in the room—and, I believe, because they did not understand the instruction as to what they were doing, their performance suffered, and when they perceived that their performance was inadequate, they attacked the simulation as a method of learning." (Contextual Interview Transcript Nurse, p. 8)

Such difficulties, however, did not occur frequently (Contextual Interview Transcript Nurse, p. 8).

One indicator of the growing presence of simulation in medical education is the explanation by one of the physician faculty members of previous personal experience: "I guess before doing kinds of simulation, I had never had any formal simulation, other than I had been through simulation exercises as a student" (Contextual Interview Transcript Physician, p. 4). One example of a general application simulation exercise in medical school is the Objective Structured Clinical Examination (OSCE). As noted:

> "medical schools most places will do something called an OSCE which, um, they'll bring in, um, standardized patients and they'll, uh, run a student through, uh, an evaluation. And then, um,— so that was— in some ways that is what we're doing here, in that we're simulating actual medical conditions." (Contextual Interview Transcript Physician, p. 4)

Thus, precedent simulation exercises in other settings provide both impetus and parallel for the kinds of training simulation employed at the teaching hospital in this study. The use of simulation in the subject setting simultaneously refers to other examples of simulation as a general reference while targeting the simulation specifically to the purpose and design deemed paramount at the particular teaching hospital. Location-specific shaping of simulation exercises necessitates precedent content and structure from other locales. Previous experience with simulation training helps shape subsequent simulation development, as the physician faculty noted: "it's kind of been a sort of trial-and-error sort of process, I think, for some of us. Now some of us have gone towards, uh, to formal training" (Contextual Interview Transcript Physician, p. 4). The existence of formal training for simulation use suggests a concerted effort by individuals and groups to coordinate development of standardized programs instructing others in how to approach, develop, and employ simulation; such effort reflects a broader environment recognizing and engaging with simulation as a teaching and assessment tool. Recall, too, from the brief overview of simulation's history in Chapter 2, that as early as the first decades of the 20th century simulation has been employed in fields such as aviation. Although simulation in medical education has been steadily growing, certainly since the 1950s, the lack of unity in experience as reported by the medical residents suggests it has not yet achieved the kind of status that a medical course in gross anatomy has, for example.

Another interesting way to think about the increasing presence of simulation education and how it relates to individuated expressions at the teaching hospital is in regard to shared information among those undergoing the simulation training. Perhaps one sign of the establishment of a common practice—especially when considered as a mode of evaluation—is the presence of cheating. The teaching hospital grappled not with formalized cheating as a means of circumventing assessment goals and increasing the chance at ensuring better assessment outcome at heightened risk of disciplinary measure. Rather, the teaching hospital experienced a less severe form of information transfer among residents that nonetheless paralleled similar conditions in other settings. For example, according to the physician faculty member:

> "one question we always had was, 'Do residents talk to each other about the simulations?' And if they do, 'How is that transfer of information going to affect their anxiety levels going into it?' Um, and I only remember this point because doing these OSCEs as a medical student I remember one of the ways they would counteract this effect was they would switch up the, uh, the scenarios."
> (Contextual Interview Transcript Physician, p. 9)

Again, although not cheating *per se* (in the most-recognized sense of the word), the fact that the residents might exchange information about insights, direction, or content of the simulation process suggests that the simulation is seen not just as a teaching tool but as an assessment. Anytime formalized assessment comes into play, the risk of undesirable information exchange between students may occur, despite the fact that at the teaching hospital in question, the assessment was not conducted for purposes of elimination, and the residents were so informed in order to encourage full concentration on the task with reduced anxiety about performance.

In the next chapter, I will revisit some of the issues related to limitations of the study and the setting in which it occurred as I make a case for the place of this study within the research field. The discussion will include findings drawn from the results, and will make recommendations for practice and further research possibilities.

Chapter 5: Discussion

The discussion in this chapter comprises four main parts: limitations and challenges of the study, findings, implications for practice, and implications for research. The section on Findings is further divided into four sub-sections. Because this project of research has been an exploratory examination of some factors related to simulation education in a medical setting, I attempt in this chapter to include not only findings, but also prompts to further questions informed by this particular exploration. Any endeavor to examine, analyze, and offer interpretations necessarily arrives at new territory in the form of new questions. This is the essence of scientific exploration, wherein the geography of previous understanding prepares us for new reaches of unfamiliar ground; as our perspective grows, so too does knowledge, and consequently the complexity of the model by which we grapple with experience.

LIMITATIONS AND CHALLENGES.

Before discussing findings and their importance, I want to review the challenges I encountered in conducting this research. Reviewing limitations of the setting, study, participants, and measures helps ground the study within the larger body of educational research, eschewing aspirations to ideological panacea, and embracing not only the need for multiple perspectives, experiences, and research projects, but also the value of those additional contributions that constitute the greater structure of scientific understanding.

Limitations of the setting and study.

Much can be differentiated in teaching hospitals across various locations, and no one setting encompasses a Platonic ideal. A busy medical center in a bustling urban center may express different characteristics—and chart a different path—than an equally busy but geographically different suburban location. Even medical centers located in more remote regions with lower human traffic may still see themselves as places of learning in the training of staff, even if not so formally acknowledged.

Lack of strict control.

In the case of this study, the teaching hospital in question was a medium-sized hospital in the urban portion of a large city in the southwest of the United States. The hospital had certain advantages in available faculty and staff, simulation technology and training facilities, and connection with academic medical institutions of good repute. Nevertheless, the research conducted for this study had to occur at some distance, in the sense that any procedure undertaken to collect data and observe procedure could not interfere with the vital work of training future professionals in health care practice. As such, strictest laboratory-level control of setting, time, participants, and even procedure could not reliably occur. Further, any study operation had to adhere to the established curricula already in place within the setting, rather than defining a new aspect of curricula, or interrupting the normal course of instruction established by the institution. At no time could I dictate which residents would be available to participate, nor which faculty and staff would oversee the simulation operation. The choice of simulation from among seven possible scenarios ultimately came down to one, the atrial fibrillation case, to ease data gathering while simultaneously narrowing the range of possible exercises in which to observe and measure participants.

Time constraints.

As mentioned in Chapter 3, one of the most important resources available to health care professionals is time, a factor equally vital to human subjects research, and however philosophical, perhaps time is one of the most important components in any human experience, inextricably linked to it as we are. Conducting this research fell under constraints of time, as limited numbers of participants were available in any given moment to respond to the surveys. In some cases, simultaneous simulations were conducted in other parts of the hospital's education facility to which I, as a researcher working alone, simply could not access to distribute surveys, instruct participants, collect data, and observe. Furthermore, the hospital's teaching curricula included much more than only simulation exercises, and the amount of time available to students to engage in simulation training was narrowly restricted to certain periods.

Self-selection of participants.

Another factor limiting this research was the population in question is a necessarily self-selecting group (medical residents), which risked limitations on discernible variability in responses and measures. Not all residents have the same background, experience, content knowledge, nor even quality of pre-medical and medical school training, making it more difficult to isolate features such as cognitive load as an influence on variability in anxiety, for example. Additionally, as previously acknowledged, the ultimate number of participants resulted in a sample size of 20, reducing the possibility that study findings might be generalized to a larger population of residents nationwide—or, indeed, globally—in simulation exercises as part of their ongoing medical education.

Measuring cognitive load.

Finally, the uncertain factor of measuring or capturing the experience of cognitive load presented an undeniable obstacle. Future study efforts in the field of medical education and the construct of cognitive load should also incorporate efforts to diversify the way cognitive load is assessed and traced. Self-report offers the advantage of ease, but eschews information that might be captured via more direct observations, including experimental and neurophysiological methods such as fMRI, for example. Although my study addressed questions about cognitive load, and assessed the experience among residents, I can by no means claim comprehensive insight into the construct and its effects.

The setting as an advantage.

With all of that in mind, however, consider that even the limitations of setting and study parameters come with a feature that might reasonably be catalogued as an advantage. The research I conducted may contribute to the larger body of educational exploration by representing observation and analysis of the teaching hospital *in situ*. Expanding educational knowledge includes the tightly controlled laboratory setting as well as the more dynamic and less-reliably consistent setting outside of laboratory control. Although the setting makes it more difficult to generalize results, it also presents an important opportunity to encompass multitudes by adding a precise, localized perspective to the broader collection of medical education.

OVERALL FINDINGS

In the next section, I outline several findings from my study and discuss their integration into the larger body of research with regard to medical education and simulations.

Finding 1: Statistically significant reduction in anxiety.

As noted in Chapter 4, comparison of the means in anxiety from the pre-simulation survey and the post-simulation survey showed a statistically significant difference, with the post-simulation value less than the pre-simulation value at a significance of $p < .01$. This suggests that residents' self-perception of anxiety following the simulation was different from the self-perception of anxiety anticipated prior to the simulation. Moreover, the statistically significant decrease demands attention, for limits on their generalizability, these results inform any consideration of the role of the simulation exercise in the specific, localized arena of the teaching hospital where the research was conducted.

One reason this result is important lies in the relationship of the teaching tool (the simulation) to the experience of anxiety in the development of the developing medical professional. In the review of the literature in Chapter 2, it was noted that one of the proposed advantages of the simulation as an instructional component is in the ability of students to learn content, procedures, and skills without risk of genuine harm to a viable, living patient (Bashankaev et al., 2011; Cant & Cooper, 2009; Davoudi & Colt, 2009; Hilty et al., 2006; Kneebone et al., 2003; Maran & Glavin, 2003). In other words, to practice necessary developmental skills and knowledge with a simulation is to do so within a context of pronounced safety for all involved. Simulated patients risk no genuine harm; meanwhile, students engaged in learning enjoy reduced psychological burden, buttressed as they are in the knowledge that mistakes impart no injury, and that pace and conduct of the exercise may take place in time and manner managed as necessary in order to review procedure, augment understanding, correct errors, highlight successes, and encourage advantageous decision-making.

It is worth noting that in contextual interview, the registered nurse reported, "Relative to nursing, the National Council of State Boards of Nursing recently, uh, published a large study—a multiple year study—where they have determined that clinical hour time and simulation hour time is equivalent" (Contextual Interview Nurse, p. 21). The implication of the significant reduction in self-report of anxiety in the present study suggests an important component for the local hospital to consider: The role of simulation as a safe teaching tool that not only imparts skill, content, and procedural knowledge, but also provides opportunity for residents (and others) to negotiate the psychological anxiety that potentially attends any medical encounter. Combined with the value of simulation training as comparable to the same amount of time in a clinical setting, the reduction in anxiety bolsters the importance of teaching hospitals employing simulations as an important and worthwhile component of curricula.

Finding 2: The factor of cognitive load in perception of anxiety.

One of the interesting statistics to emerge from this study is the degree of association between the self-reported perceptions of cognitive load and performance anxiety during the exercise. As noted in Chapter 4, the correlation between pre- and post-simulation anxiety was 0.73, and again, the absence of a perfect (or near-perfect) correlation suggests something changed for the residents between the time just prior to the start of the simulation and the moments following the end of the exercise. As the decrease in means between the pre-simulation and post-simulation anxiety showed, the change recognized and indicated by the residents was a lowering in the overall levels of anxiety. Could the element of cognitive load be a factor in the change? The relations between these factors pose an interesting possibility.

The correlation between pre-simulation anxiety and cognitive load showed an essentially negligible 0.04, and again, as noted in Chapter 4, this value makes sense. Prior to the start of the simulation, the residents would have little or no point-of-reference for the experience of cognitive load relative to the simulation itself because the simulation had not yet begun. Intrinsic load of the exercise itself was not yet underway, germane load as a targeted component to promote learning was as yet unknown, and extraneous load that would reduce the learners' ability to concentrate on the germane components was as yet undiscovered. However, the correlation between post-simulation anxiety and cognitive load showed a moderate relationship of 0.42, suggesting that some dynamic exists between the factor of cognitive load and the significant decline in anxiety as reported by the residents.

What is particularly interesting about this relationship is that the correlation is moderate, rather than low or high. A much lower correlation might not warrant further examination of cognitive load, at least not without attempting to capture other factors that might be influential, as well. By contrast, absence of a higher correlation suggests that cognitive load alone does not represent the only factor worth examining relative to change in reported anxiety. Yet the change in anxiety did occur, was significant, and demonstrated an effect size bordering on strong with a value of 0.53, suggesting that cognitive load may have contributed somehow to the perceived change. This is important because it reflects on the continued need not only to examine the role cognitive load plays in medical education, but also the need within the field of educational research to develop better methods of capturing cognitive load. Indeed, it may be that one reason the relation between cognitive load and post-simulation anxiety is somewhat murky in this study is because the self-report measure may not adequately describe the actual experience of cognitive load among residents. Because cognitive load has multiple components (Fraser et al., 2012), more precise measures would promote better differentiation of the various components of cognitive load, allowing researchers to isolate those aspects of intrinsic, germane, and extraneous load that are pertinent to the affective experience of learners undergoing simulation training. Although the cognitive load questionnaire in this study did attempt to isolate the three different types of load in a rudimentary manner, the survey was not likely a precise assessment. Furthermore, another aspect that this study did not capture was the development of schema, which Schnotz & Kürschner (2007) described as signposts that cognitive load has contributed to learning.

Thus, test of the relation between cognitive load and post-simulation anxiety further elucidate the presence of some factor exerting some influence, and reinforce the understanding that cognitive load remains a somewhat elusive construct requiring further study and development of better instruments. It may be that the questionnaire I used in this study may one day enter the body of literature as one component in extracting information about cognitive load during simulation exercises, but future research would need to test the instrument further, establish reliability and validity vis-à-vis the construct of cognitive load (itself requiring further research), and would likely require combining with other measures.

Finding 3: Standardization is desirable albeit limited.

Portions of the interviews with the registered nurse and the physician faculty member touched on the issue of standardization of simulations. In their commentary I saw them describing the challenge of standardization of a given experience within the local hospital setting, and alluded to the broader development of standardized simulations in medical education in general. The presence of simulations available to use or model other simulations suggests a measure of standardization is possible. Indeed, a portion of technical industries that provide medical and educational tools manufactures simulation components such as mannequins and attendant software with the understanding that the devices can be used in multiple settings and multiple ways for teaching multiple content areas.

However, it remains critical to the successful integration and application of simulations that the devices are targeted to specific settings and needs. A certain degree of customization—or at least elasticity—must be built into simulations at the broadest level in order to allow them to be integrated effectively at the education site level. Different locations attempting to create successful simulation training may look to standardized models as baseline components, but those institutions must necessarily tailor the simulations and relevant components to their own student populations, learning goals and outcomes, and even the simple geography of their facilities.

In addition, a tension may arise between simulation users. The allure of the standardized device to provide an equal and exact training experience each time may be strong, but such also risks detachment from the actual encounters with patients that medical professionals will undertake hundreds and thousands of times during the course of their careers. Health conditions may contain basic underlying aspects that unify across all humans, but health conditions also express in diverse ways across diverse populations.

A simulation that is the same every time may exhibit excellent reliability within the exercise itself, but in the course of caring for living patients no health care provider is ever likely to have exactly the same experience every time. The volume of human variables that diversify the species represents a vast array to manage in such a way that a single, reliable baseline human is unlikely to appear very frequently. Although simulation standardization has advantages in assessment of students, for example, it does not necessarily broaden the students' base of experience for the wider human population that will eventually approach for medical care. Standardization may actually not allow the simulation to teach the highest level of performance, which would be the ability to adapt to the wide varieties of ways that even a single disease may present itself. Because the process of diagnosis is both multi-dimensional and iterative, a standardized simulation may be insufficient to teach that level of metacognitive skill. A more sophisticated approach is a simulation that may be readily and dynamically customized even within a specific simulation exercise to mirror more faithfully the variability in real life experience of a disease or condition. This would allow instructors to emphasize in learners the metacognitive skill of monitoring thinking and continuing the search for information in order to arrive at a correct diagnosis, which in turn improves the probability of effective treatment and outcome. One important component of diagnostic skill is the ability to ignore that which is irrelevant, and find the key symptoms that go together to make an accurate diagnosis without jumping to conclusions. Thus, one of the important aspects of this research is the acknowledgement that institutions must customize their simulation to meet their educational needs, and this includes managing the tension between standardization that provides training across all students and the diversification that helps prepare students for the variation in human patients. This potential for customization must also recognize the variation in students, for despite foundational components common to many medical education programs, diversity in doctors emerges at different places, times, and circumstances.

IMPLICATIONS FOR PRACTICE

I note again that a simulation is a tool, not a panacea, so the seduction of technology must not overcome the critical examination of how and when and where to best employ the technology. In other words, the underlying educational goals should dictate the presence and employment of the simulation, rather than the simulation dictating the curriculum. First and foremost, in medical education is the growth and mentoring of future health care providers, and simulations should abet that endeavor, rather than standing as a point of prestige or allure to outsiders. As with any tool or technology, caution must be exercised in employment to avoid the deceptively easy assumption that the tool solves a problem. Instead, simulation users must consider the ways in which the tool must be manipulated in order to solve problems, reinforcing the necessary agency of the people in the learning environment.

The correlation found between cognitive load and post-simulation performance anxiety should be taken into consideration by the local hospital to allow users to manipulate the effect of the simulation once the intervening variables are understood. So instructional recommendations derived from this study include such aspects as the design of future simulations, the integration of simulations into curriculum, the use of simulation for assessment, and paying attention to intervening variables such as cognitive load factors that may be controllable.

In medical settings, the cognitive load can be great, so there are implications for training students to manage cognitive load, rather than just weather it. There are also implications for instructors to learn to recognize cognitive load. This has application for both curriculum and instructional design, as well as on-the-spot instruction, for example, the development of the short instructional scripts that can quickly convey important information. This kind of study and future research that emerges from it has relevance not only for current students, but also for instructors, and in medicine practice in general, because at some point every practitioner who was a student will become an instructor of patients as well as staff in turn. Being able to recognize and appreciate how much cognitive load a patient is experiencing in the moment would be an important aid in doctor-patient communication.

Consider a classic—and profound—condition with significant psychological weight: the cancer diagnosis. The simple pronouncement of the word "cancer" can carry immense implication to an individual. As a patient grapples with the intrinsic load of such a diagnosis, physicians should be aware of that immensity when trying to provide indications for treatment, medication, and prognosis. Such germane elements risk losing out to the heft of the looming specter of "cancer." Knowledge of cognitive load as a component may help future physicians—as well as present practitioners—recognize the difficulties of trying to navigate a cancer diagnosis discussion and approach follow-up information with a different load to enhance management and promote germane load necessary for the patient's learning.

IMPLICATIONS FOR RESEARCH

The correlation between cognitive load and post-simulation performance anxiety perception is also fertile ground for future research because it is possibly an important intervening variable in interprofessional communication. Communication between members of a medical team needs to be enhanced to avoid treatment errors, as was found in the early research on cockpit crews (Bashankaev et al., 2011; Koonce & Bramble, 1998; Okuda et al., et al., 2009). I would assert that there are many similar constructs in current educational and psychological research that need exploring in medical education settings, particularly those like simulations that are becoming key to learning in medicine.

Future research should also explore the possibility of triangulating psychological measurement in medical education with physiological data from tools such as (f)MRI. Such efforts would enhance the probability of deeper understanding of constructs and factors active in learning among medical personnel, not only at foundational times such as during medical school, but also for professional development and continuing education of established health care practitioners. In addition, an expanded list of variables worth including in future research endeavors includes elements such as descriptive demographics, level of previous experience with simulations, native language, and whether or not assessment of performance during the simulation is occurring, to name just a few.

CONCLUSION

As a final note, one of the most important realizations I carry away from observing these residents undergo simulation education has been the understanding that medicine—as a practice and as an environment of learning—incorporates a broader scope of disciplines than the elements of medical care predicated solely on biological knowledge. This by no means invalidates the vastly important natural science foundation necessary for contemporary, evidence-based medical practice and the continued growth of medicine toward ever-improving understandings of human health. However, it is clear that medicine is not only a physical science, but also a social science, conducted as it is among humans and invoking extremely crucial components of communication, empathy, emotion, relationships, understanding, and learning. Consider the words of the registered nurse Gabrielle from interview:

> "I coached the faculty when they were conducting their simulations about keeping the consistency from one learner to the next is— is so important to collect the science that is not all over the place, you know, the data we want is— is significant; to not help the residents too much because failure is still a learning experience, and I think that was a big mental hurdle for them to get over, was [sic] they wanted all the residents to do well so they were maybe giving hints where they should not have given the hints, ok?" (Contextual Interview Transcript Nurse, p. 2)

Therefore, as medicine advances, so too must medical education advance, and the evolving arena of teaching and learning relative to the practice of medicine must continue the journey it has recently begun. That journey is one incorporating psychology and sociology in order to understand not just medicine, but the ways in which the practice of medicine intersects and affects the very humans entrusted to its care. Alongside best practices of diagnosis and treatment, health care communities would do well to understand what it means to communicate with people about their health, what it means to instruct future generations of health care professionals, and also what it means to undertake the necessary self-reflection to maintain curiosity about one's own learning long after formal classroom training has passed. The future of medicine is not simply in more advanced pharmaceuticals and more sophisticated technologies of diagnosis. Generations to come must grapple not only with the pathogens and incidents of human physiology, but also the ways people interact with and are affected by such occurrences in their daily lives. Alongside the innumerable and incalculably valuable contributions of chemists, physicists, and biologists, medicine's venture to incorporate psychology and sociology means the discipline will not only survive, but thrive. In its complexity, the natural science of medicine has grown to be a social science, as well.

Appendices

APPENDIX A: PRE-SIMULATION PERFORMANCE ANXIETY QUESTIONNAIRE

Instructions: The following statements are presented to help understand the experience of anxiety in the context of simulation exercises and assessments. There are no right or wrong answers. Simply answer each question as accurately as possible about your experience. If you think a statement about the upcoming simulation exercise is very true of you, circle the number 7; if a statement is not at all true of you, circle the number 1. If a statement is more or less true of you, circle the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
not at all true of me						very true of me

1. I am nervous about my participation in this simulation.	1	2	3	4	5	6	7
2. During simulations or other assessments I think about how poorly I am doing compared with others.	1	2	3	4	5	6	7
3. I never have doubts about my ability to succeed during simulations.	1	2	3	4	5	6	7
4. During simulations or other assessments I think about challenges with which I have difficulty.	1	2	3	4	5	6	7
5.When I take simulations or other assessments I think of the consequences of failing.	1	2	3	4	5	6	7
6. I have an uneasy, upset feeling during a simulation or other assessment.	1	2	3	4	5	6	7
7. I feel my heart beating fast during a simulation or other assessment.	1	2	3	4	5	6	7

Name (please print): ____

Age: __________ Anticipated Medical Specialty: ____________________

Appendix B: Post-Simulation Performance Anxiety Questionnaire

Instructions: As before, the following statements are presented to help understand the experience of anxiety in the context of simulation exercises and assessments. There are no right or wrong answers. Simply answer each question as accurately as possible about your experience. If you think a statement about the simulation exercise you just underwent is very true of you, circle the number 7; if a statement is not at all true of you, circle the number 1. If a statement is more or less true of you, circle the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
not at all true of me						very true of me

1. I was nervous about my participation in this simulation.	1	2	3	4	5	6	7
2. During this simulation I thought about how poorly I was doing compared with others.	1	2	3	4	5	6	7
3. During this simulation I thought about challenges with which I was having difficulty.	1	2	3	4	5	6	7
4. During this simulation I thought about the consequences of failing.	1	2	3	4	5	6	7
5. I am always willing to admit when I make a mistake during simulation training.	1	2	3	4	5	6	7
6. I had an uneasy, upset feeling during this simulation.	1	2	3	4	5	6	7
7. I felt my heart beating fast during this simulation.	1	2	3	4	5	6	7

Name (please print): ____

Is English your first or native language (please circle)?   Yes   No

APPENDIX C: COGNITIVE LOAD AND FIDELITY QUESTIONNAIRE

Instructions: The following statements are presented to help understand experiences of cognitive load during simulation exercises and assessments. There are no right or wrong answers. Simply answer each question as accurately as possible about your experience. If you think a statement about the simulation exercise describes a condition that occurred constantly, circle the number 7; if a statement describes a condition that did not occur at all, circle the number 1. If a statement describes a condition that occurred more or less frequently, circle the number between 1 and 7 that best describes your experience. Finally, please rate your perception of the realism of the simulation on a scale from 1 (not at all realistic) to 7 (very realistic).

1	2	3	4	5	6	7
did not occur at all						occurred constantly

1. Being given too much information to track adequately.	1	2	3	4	5	6	7
2. Being rushed to make decisions too quickly.	1	2	3	4	5	6	7
3. Having to take time to decide if a component of the simulation was relevant to my learning.	1	2	3	4	5	6	7
4. Having my thinking interrupted by irrelevant distractions.	1	2	3	4	5	6	7
5. Feeling confused about the details of the situation.	1	2	3	4	5	6	7
6. Feeling not in control of my thinking during the situation.	1	2	3	4	5	6	7
7. Having trouble mentally searching for relevant information about the situation.	1	2	3	4	5	6	7

Please circle how realistic you felt the simulation was on the following scale:

1 2 3 4 5 6 7

not at all realistic	very realistic

Please circle how many times previously you have worked with simulations:

None 1 to 4 times 5 to 9 times 10 or more times

Appendix D: Sample Semi-Guided Interview Questions for Faculty and Staff

When did the program start?

When did your involvement begin?

What is your role in the simulation exercises?

In order to better understand the simulation, are there any technical details about the exercise, tools, equipment, or environment you feel important to note, highlight, explain, or critique?

In how many simulations do you estimate you have participated?

To begin, what were your overall thoughts, feelings, and impressions about the simulation exercise?

I would like to ask some questions related to the concept of cognitive load, which is one of the things this study hopes to examine. Cognitive load is the amount of information an individual must grapple with during a learning exercise, and is thought to have three major components: Intrinsic load, which is the amount of information demanding cognitive attention inherent to the exercise itself, Extraneous load which is information that is irrelevant to the learning but which taxes the learner regardless, and Germaine load which is the amount of information critical to the learning exercise itself.

So, thinking about the simulation and the residents you've seen go through the simulation and the exercises you've observed, um, did you notice anything particularly irrelevant during the simulation that became a distraction, um, and what are your observations about those?

What did you feel like you discovered about residence performance and learning in your observations during the simulation?

Once a specific simulation is over, do you ever think about it later? If so, what are your thoughts?

What are some of your observations about the reactions of the residents to the simulations?

What are some of your observations about the reactions of the faculty and staff to the simulations?

What do you see that is consistent in performance on this simulation from student to student? What do you see that is different?

Are there any successes or positive aspects you would ascribe to the simulation exercises? If so, what are they?

Are there any failures or negative aspects you would ascribe to the simulation exercises? If so, what are they?

Have you observed any challenges in the development, implementation, and evaluation of the simulation exercises? If so, what are they?

What did you feel like you discovered about the simulation in general?

One of the sentiments about medicine that I've encountered is that it is both art and science. Thinking about the simulation exercise, do you have an opinion on such a sentiment?

What changes would you propose to the simulation exercises as part of the hospital's education system?

What do you think the future of the simulations is as part of the hospital's educational curriculum?

Any further thoughts about the simulations and your experience as part of them?

APPENDIX E: INFORMED CONSENT FORM

<u>Informed Consent Form</u> for participation in a research study of the experience of anxiety and cognitive load relative to performance in a medical simulation learning exercise.

What is this research about? Simulations in this research study are part of the UT-Southwestern Austin internal medicine residency program curriculum. This study is designed to examine the relationship between self-reported elements of anxiety and cognitive load relative to performance in a simulated medical teaching exercise. Although you are participating in the simulation as part of your training in the UT-Southwestern Austin internal medicine residency program, the Principle Investigator of this study request permission to gather voluntary data about your experiences in the simulation.

What will be asked of you? For each simulation in which you participate, you will be asked to complete a pre and two post surveys about your experiences during the simulation. Each simulation should run about approximately 15 to 30 minutes, and each survey should take no longer than three minutes. Some participants will be asked to be interviewed about their experiences in the simulation, though not all participants will be invited. Interviews are anticipated to take 35 to 45 minutes. If you choose to participate in this study you may be audio recorded. Total time commitment for participation is anticipated to be 55 to 80 minutes (approximately 1 hour to 1 hour 20 minutes).

What use will be made of the data? The survey data will be analyzed relative to your performance in the simulation. The results of your participation will remain confidential and could be used in aggregated form for dissertation purposes. We request permission to use your responses to the survey and the results of your simulation assessment to analyze the relationship between anxiety, cognitive load, and performance in a simulation. We also request permission to use your interview responses for qualitative analysis. Your decision to allow or not allow the use of survey responses and interview responses will also be kept confidential and will not affect your current or future relationship to the UTSW-Seton Internal Medicine Residency Program or the University of Texas at Austin.

Participation is completely voluntary, and responses to surveys and interviews will remain confidential. Any publicized results or analyses will be coded for confidentiality or pseudonymity.

What are the possible benefits of this study? You will receive no direct benefit from participating in this study, however, this study may inform the improvement of medical education in general.

What are the risks involved in this study? None, other than those normally extant to residents in an Internal Medicine education rotation and participating in medical simulation. The risk of loss of confidentiality is small but possible.

How will your privacy and confidentiality be protected if you participate in this study? Your privacy and confidentiality will be protected. Only the PI and the PI's advisor will have access to the survey and interview data, and any data reported will be done in aggregate to hide potential identifiers. Any survey and interview data will be coded for anonymity or pseudonymity to protect the identity of participants. Data will be stored in a locked office and any electronic information will be stored on a personal computer kept in a locked residence. Any audio recordings will be stored securely and only the research team will have access to the recordings. Recordings will be destroyed after transcription.

If it becomes necessary for the Institutional Review Board to review the study records, information that can be linked to you will be protected to the extent permitted by law. Your research records will not be released without your consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate it with you, or with your participation in any study.

If you are interested in participating, please complete and sign below and return the form to Robert W. Ellis.

If you have any questions about the study, please contact Robert W. Ellis at (312) 305-1022.

Whom to contact with questions concerning your rights as a research participant. For questions about your rights or any dissatisfaction with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu

Robert W. Ellis
Graduate Student and Principle Investigator, The University of Texas at Austin

I have read the letter above describing the research study being performed and I agree to participate in the research study.

____
Signature & date

Print full name and email address

APPENDIX F: FACULTY AND STAFF INFORMED CONSENT FORM

<u>Informed Consent Form</u> for participation in a research study of the experience of anxiety and cognitive load relative to performance in a medical simulation learning exercise.

What is this research about? Simulations in this research study are part of the UT-Southwestern Austin internal medicine residency program curriculum. This study is designed to examine the relationship between self-reported elements of anxiety and cognitive load relative to performance in a simulated medical teaching exercise. Although you are participating in the simulation as a faculty member evaluating medical residents, the Principle Investigator of this study requests permission to gather voluntary data about your experiences conducting the simulation.

What will be asked of you? You will be asked to be interviewed about your experiences supervising and evaluating the simulation. Interviews are anticipated to take 35 to 45 minutes. If you choose to participate in this study you may be audio recorded. Total time requested for simulation and qualitative interview for faculty is anticipated to be 55 to 80 minutes (approximately 1 hour to 1 hour 20 minutes).

What use will be made of the data? We request permission to use your interview responses for qualitative analysis. Your decision to allow or not allow the use of interview responses will be kept confidential and will not affect your current or future relationship to the UTSW-Seton Internal Medicine Residency Program or the University of Texas at Austin.

Participation is completely voluntary, and responses to interviews will remain confidential. Any publicized results or analyses will be coded for confidentiality or pseudonymity.

What are the possible benefits of this study? You will receive no direct benefit from participating in this study, however, this study may inform the improvement of medical education in general.

What are the risks involved in this study? None, other than those normally extant to faculty and staff in an Internal Medicine education rotation and supervising medical simulation. The risk of loss of confidentiality is small but possible.

How will your privacy and confidentiality be protected if you participate in this study? Your privacy and confidentiality will be protected. Only the PI and the PI's advisor will have access to the interview data, and any data reported will be coded for anonymity or pseudonymity to protect the identity of participants. Data will be stored in a locked office and any electronic information will be stored on a personal computer kept in a locked residence. Any audio recordings will be stored securely and only the research team will have access to the recordings. Recordings will be destroyed after transcription.

If it becomes necessary for the Institutional Review Board to review the study records, information that can be linked to you will be protected to the extent permitted by law. Your research records will not be released without your consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate it with you, or with your participation in any study.

If you are interested in participating, please complete and sign below and return the form to Robert W. Ellis.

If you have any questions about the study, please contact Robert W. Ellis at (312) 305-1022.

Whom to contact with questions concerning your rights as a research participant.
For questions about your rights or any dissatisfaction with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu

Robert W. Ellis
Graduate Student and Principle Investigator, The University of Texas at Austin

I have read the letter above describing the research study being performed and I agree to participate in the research study.

____
Signature & date

____
Print full name and email address

References

Akl, E. A., Pretorius, R. W., Sackett, K., Erdley, W. S., Bhoopathi, P. S., Alfarah, Z., & Schüenamann, H. J. (2010). The effect of educational games on medical students' learning outcomes: A systematic review: BEME Guide No 14. *Medical Teacher, 32*, 16-27.

American Medical Association. (2013). Accelerating change in medical education. Retrieved from http://www.ama-assn.org/resources/doc/about-ama/accelerating-change-in-medical-education.pdf

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal Of Psychoeducational Assessment*, *27*(3), 197-205. doi:10.1177/0734282908330580

Bandali, K., Parker, K., Mummery, M., & Preece, M. (2008). Skills integration in a simulated interprofessional environment: An innovative undergraduate applied health curriculum. *Journal of Interprofessional Care, 22*(2), 179-189.

Bashankaev, B., Baido, S., & Wexner, S. D. (2011). Review of available methods of simulation training to facilitate surgical education. *Surgical Endoscopy, 25*, 28-35.

Birjandi, P., & Alemi, M. (2010). The impact of test anxiety on test performance among Iranian EFL learners. *BRAIN: Broad Research In Artificial Intelligence & Neuroscience*, *1*(4), 44-58.

Cant, R. P., & Cooper, S. J. (2009). Simulation-based learning in nurse education: Systematic review. *Journal of Advanced Nursing, 66*(1), 3-15.

Casado, M., Castano, G., & Arraez-Aybar, L. (2012). Audiovisual material as educational innovation strategy to reduce anxiety response in students of human anatomy. *Advances In Health Sciences Education*, *17*(3), 431-440.

Cook, D. A., Hamstra, S. J., Brydges, R. Zendejas, B. Szostek, J. H., Wang, A. T., Erwin, P. J., & Hatala, R. (2013). Comparative effectiveness of instructional design features in simulation-based education: Systematic review and metaanalysis. *Medical Teacher, 35*(1), 867-898. doi:10.3109/0142159X.2012.714886

Cooper, J. B., & Taqueti, V. R. (2008). A brief history of the development of simulators for clinical education and training. *Postgraduate Medical Journal, 84*, 563-570.

Davoudi, M., & Colt, H. G. (2009). Bronchoscopy simulation: A brief review. *Advances in Health Science Education, 14*, 287-296.

Doctor, R. M., Kahn, A.P., & Adamec, C. (2008). Performance anxiety. In *Facts on File Library of Health and Living*. *The Encyclopedia of Phobias, Fears, and Anxieties,* (3rd ed., pp. 378-380). New York: Facts on File. Retrieved from: http://go.galegroup.com.ezproxy.lib.utexas.edu/ps/i.do?p=GVRL&sw=w&u=txshracd2598&v=2.1&it=r&id=GALE%7CCX4058501250&asid=b7e18e03cb7fa03866de36b400841c34

Fraser, K., Ma, I., Teteris, E., Baxter, H., Wright, B., & McLaughlin, K. (2012). Emotion, cognitive load and learning outcomes during simulation training. *Medical Education*, *46*(11), 1055-1062. doi:10.1111/j.1365-2923.2012.04355.x

Finkelstein, C., Brownstein, A., Scott, C., & Yu-Ling, L. (2007). Anxiety and stress reduction in medical education: an intervention. *Medical Education*, *41*(3), 258-264. doi:10.1111/j.1365-2929.2007.02685.x

Garbee, D. D., Paige, J., Barrier, K., Kozmenko, V., Kozmenko, L., Zamjahn, J., & ... Cefalu, J. (2013). Interprofessional teamwork among students in simulated codes: A quasi-experimental study. *Nursing Education Perspectives*, *34*(5), 339-344.

Grice, G., Wenger, P., Brooks, N., & Berry, T. (2013). Comparison of Patient Simulation Methods Used in a Physical Assessment Course. *American Journal Of Pharmaceutical Education*, *77*(4), 1-5.

Harvey, A., Nathens, A. B., Bandiera, G., & LeBlanc, V. (2010). Threat and challenge: cognitive appraisal and stress responses in simulated trauma resuscitations. *Medical Education*, *44*(6), 587-594. doi:10.1111/j.1365-2923.2010.03634.x

Hayes, K. K., Feather, A. A., Hall, A. A., Sedgwick, P. P., Wannan, G. G., Wessier-Smith, A. A., & ... McCrorie, P. P. (2004). Anxiety in medical students: is preparation for full-time clinical attachments more dependent upon differences in maturity or on educational programmes for undergraduate and graduate entry students? *Medical Education*, *38*(11), 1154-1163. doi:10.1111/j.1365-2929.2004.01980.x

Hauber, R. P., Cormier, E., & Whyte IV, J. (2010). An exploration of the relationship between knowledge and performance-related variables in high-fidelity simulation:

Designing instruction that promotes expertise in practice. *Nursing Education Perspectives*, *31*(4), 242-246.

Hilty, D. M., Alverson, D. C., Alpert, J. E., Tong, L., Sagduyu, K., Boland, R. J., … Yellowlees, P. (2006). Virtual reality, telemedicine, web and data processing innovations in medical and psychiatric education and clinical care. *Academic Psychiatry, 30*, 528-533.

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Gordon, D. L., Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10-28.

Kneebone, R. L., Nestel, D. D., Moorthy, K. K., Taylor, P. P., Bann, S. S., Munz, Y. Y., & Darzi, A. A. (2003). Learning the skills of flexible sigmoidoscopy--the wider perspective. *Medical Education*, *37,* 50-58. doi:10.1046/j.1365-2923.37.s1.2.x

Kohn, K. T., Corrigan, J.M., Donaldson, M. S. (1999). *To Err is Human: Building a Safer Health System*. Washington, DC: National Academy Press.

Koonce, J. M., & Bramble, W. J. (1998) Personal computer-based flight training devices. *The International Journal of Aviation Psychology, 8*(3), 277-292.

Laschinger, S., Medves, J., Pulling, C., McGraw, R., Waytuck, B., Harrison, M. B., & Gambeta, K. (2008). Effectiveness of simulation on health profession students' knowledge, skills, confidence and satisfaction. *International Journal of Evidence Based Healthcare, 6*, 278-302.

Lee, J., & Graham, A. (2001). Students' perception of medical school stress and their evaluation of a wellness elective. *Medical Education*, *35*(7), 652-659.

Linnell, K. J., & Caparos, S. (2011). Perceptual and cognitive load interact to control the spatial focus of attention. *Journal of Experimental Psychology: Human Perception And Performance*, *37*(5), 1643-1648. doi:10.1037/a0024669

Maran, N. J., & Glavin, R. J. (2003). Low- to high-fidelity simulation—a continuum of medical education? *Medical Education, 37*(1), 22-28.

Marken, P., Zimmerman, C., Kennedy, C., Schremmer, R., & Smith, K. (2010). Human simulators and standardized patients to teach difficult conversations to interprofessional health care teams. *American Journal Of Pharmaceutical Education*, *74*(7), 1-8.

Marshall, S. D., & Flanagan, B. (2010). Simulation-based education for building clinical teams. *Journal of Emergencies, Trauma, and Shock, 3*(4), 360-368.

May, W., Park, J. H., & Lee, J. P. (2009). A ten-year review of the literature on the use of standardized patients in teaching and learning: 1996-2005. *Medical Teacher, 31,* 487-492.

McGaghie, W. C., Issenberg, S. B., Petrusa, E. R., & Scalese, R. J. (2006). Effect of practice on standardized learning outcomes on simulation-based medical education. *Medical Education, 40,* 792-797.

McGaghie, W. C., Issenberg, S. B., Petrusa, E. R., & Scalese, R. J. (2016). Revisiting "A critical review of simulation-based medical education research: 2003-2009." *Medical Education, 50*, 986-991. doi:10.1111/medu.12795

McNaughton, N., Ravitz, P., Wadell, A., & Hodges, B. D. (2008). Psychiatric education and simulation: A review of the literature. *The Canadian Journal of Psychiatry, 53*(2), 85-93.

Okuda, Y., Bryson, E. O., DeMaria, S., Jacobson, L., Quinones, J., Shen, B., & Levine, A. I. (2009). The utility of simulation in medical education: What is the evidence? *Mount Sinai Journal of Medicine, 76*, 330-343.

Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. M. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, *38*(1), 63-71.

Paskins, Z., & Peile, E. (2010). Final year medical students' views on simulation-based teaching: A comparison with the Best Evidence Medical Education Systematic Review. *Medical Teacher*, *32*(7), 569-577. doi:10.3109/01421590903544710

Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Education and Psychological Measurement, 53*, 801-813.

Reteguiz, J. (2006). Relationship between anxiety and standardized patient test performance in the medicine clerkship. *JGIM: Journal of General Internal Medicine*, *21*(5), 415-418. doi:10.1111/j.1525-1497.2006.00419.x

Rutherford-Hemming, T., & Jennrich, J. (2013). Using standardized patients to strengthen nurse practitioner competency in the clinical setting. *Nursing Education Perspectives*, *34*(2), 118-121.

Ryan, C., & Andrews, N. (2009). An investigation into the choral singer's experience of music performance anxiety. *Journal of Research in Music Education*, *57*(2), 108-126.

Schnotz, W., & Kürschner, C. (2007). A reconsideration of cognitive load theory. *Educational Psychology Review*, *19*(4), 469-508.

Schout, B. M. A., Ananias, H. J. K., Bemelmans, B. L. H., d'Ancona, F. C. H., Muijtjens, A. M. M., Dolmans, V. E. M. G., … & Hendrikx, A. J. M. (2010). Transfer of cysto-urethroscopy skills from a virtual-reality simulator to the operating room: A randomized controlled trial. *British Journal of Urology International, 106*, 226-231.

Shokrpour, N., Zareii, E., Zahedi, S. S., & Rafatbakhsh, M. M. (2011). The impact of cognitive and meta-cognitive strategies on test anxiety and students' educational performance. *European Journal of Social Science*, *21*(1), 177-188.

Sloan, T., Lundin, M., Wilson, D., & Robinnette, R. (2010). The use of test anxiety assessment and anxiety reduction training to predict and improve performance of collegiate pilot trainees. *Collegiate Aviation Review*, *28*(2), 60-68.

Takayesu, J. K., Nadel, E. S., Bhatia, K., & Walls, R. M. (2010). Incorporating simulation into residency curriculum. *Canadian Journal of Emergency Medicine, 12*(4), 349-353.

van Merriënboer, J. G., & Sweller, J. (2010). Cognitive load theory in health professional education: design principles and strategies. *Medical Education*, *44*(1), 85-93. doi:10.1111/j.1365-2923.2009.03498.x

Vitasari, P., Wahab, M. N. A., Othman, A., Herawan, T., Sinnadurai, S. K. (2010). The relationship between study anxiety and academic performance among engineering students. *Procedia: Social and Behavioral Sciences, 8*, 490-497.

Vita

Robert Williams Ellis came to the field of educational psychology after an undergraduate degree in English literature and eleven years working in private sector business. His work experience includes time as manager of the creative production department of an internationally distributed retail catalog company. During his graduate studies he worked as a teaching assistant for courses related to psycholinguistics and the psychology of teachers and teaching. His research interests include various aspects of medical education and professional development in medicine. Dr. Ellis is a resident of Brookfield, Illinois.

Permanent address (or email): 3635 Madison Avenue, Brookfield, Illinois 60513

This dissertation was typed by Robert Williams Ellis.