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Cognitive Load Theory Principles Applied to Simulation Instructional Design for Novice Health Professional Learners

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Cognitive Load Theory Principles Applied to Simulation Instructional Design
for Novice Health Professional Learners

by

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A dissertation submitted in partial fulfillment of the requirements for the
degree of Doctor of Philosophy

Nova Southeastern University
Dr. Pallavi Patel College of Health Care Sciences
Department of Physical Therapy
2019

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Abstract

While the body of evidence supporting the use of simulation-based learning in the education of health professionals is growing, *how* or *why* simulation-based learning works is not yet understood. There is a clear need for evidence, grounded in contemporary educational theory, to clarify the features of simulation instructional design that optimize learning outcomes and efficiency in health care professional students.

Cognitive Load Theory (CLT) is a theoretical framework focused on a learner's working memory capacity. One principle of CLT is example based learning. While this principle has been applied in both traditional classroom and laboratory settings, and has shown positive performance and learning outcomes, example based learning has not yet been applied to the simulation setting. This study had two main objectives: to explore if the example-based learning principle could successfully be applied to the simulation learning environment, and to establish response process validation evidence for a tool designed to measure types of cognitive load.

Fifty-eight novice students from nursing, podiatric medicine, physician assistant, physical and occupational therapy programs participated in a blinded randomized control study. The dependent variable was the simulation brief. Participants were randomly assigned to either a traditional brief or a facilitated tutored problem brief. Performance outcomes were measured with verbal communications skill presented in the Introduction, Situation, Background, Assessment, Recommendation (I-SBAR) format. Response process evidence was collected from cognitive interviews of 11 students.

Results indicate participation in a tutored problem brief led to statistically significant differences at $t(52)=-3.259, p=.002$ in verbal communication performance

compared to students who participated in a traditional brief. Effect size for this comparison was $d=(6.06-4.61)/1.63 = .89$ (95% CI 0.32-1.44). Response process evidence demonstrated that additional factors unique to the simulation learning environment should be accounted for when measuring cognitive load in simulation based learning (SBL).

This study suggests that example based learning principles can be successfully applied to SBL and result in positive performance outcomes for health professions students. Additionally, measures of cognitive load do not appear to capture all contribution to load imposed by the simulation environment.

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Chapter 1 Introduction

1.0 Introduction

Simulation based learning (SBL) is widely utilized across health professions educational programs and is recognized as an educational intervention with potential to facilitate the growth of transformational learners ready for collaborative practice environments. National and global agencies recognize the untapped potential of SBL as a key educational modality in the training of future health professionals.^{1,2} The literature shows that technology-enhanced simulation when compared to other instructional interventions (or no intervention), in training health professionals is associated with positive effects for knowledge, skills, behavioral, and patient related outcomes.³⁻⁵ What remains unanswered is specifically *how* learning through simulation modalities works, *why* it works, and *for whom* it optimally works.⁶ Quality research is needed to provide insight into these questions. Those in the field of health professions educational research strongly recommend that the focus of future research in SBL move beyond general questions of "is simulation effective?" and toward questions that provide insight into which factors and instructional methods have positive influences on learning.⁵⁻⁸

1.1 Statement of the Problem

Understanding what constitutes optimal curricular design in SBL for learners in the health professions is in its infancy. One reason suggested is that the questions driving research in SBL do not clearly define the constructs of study.⁹ In order to both optimize the potential for knowledge development, and gain complex problem-solving and teamwork

skills, a body of quality evidence is needed to guide educators in how best to structure SBL. Systematic reviews of the literature demonstrate that SBL is full of inconsistency in terms of learner groups studied, instructional design standards, research methods, and outcome measures used.^{5-8,10} The inconsistency across the literature limits inferences that can be made regarding the most effective and efficient use of SBL . One of the main reasons for these inconsistencies is a lack of grounding SBL in contemporary educational theories and frameworks.^{5,6,10} By using established and contemporary educational theories to ground research in SBL, the focus on *learning rather than teaching* outcomes is possible. Generating this body of theory grounded evidence provides the ability to generalize between studies that evaluate instructional designs and strategies. Currently this ability is limited due to the lack of theoretical grounding.⁵

1.2 Relevance and Significance

Several health professions educational researchers propose the application of Cognitive Load Theory (CLT) as a useful contemporary educational framework for grounding research in SBL.¹¹⁻¹³ The foundation of Cognitive Load Theory is in human cognitive architecture: the process and the product of planning and constructing knowledge and understanding.¹⁴ The theory is concerned with how information provided during instruction interacts with this architecture during the process of learning.¹⁵ It emphasizes working memory (WM) constraints as the primary determinant of effective instruction.^{15,16} It assumes that performance and learning are impaired when the cognitive demands associated with a learning activity exceed a learner's limited WM capacity, creating a state of cognitive overload.^{15,17,18} Example-based learning is a well-studied

educational principle developed from CLT.¹⁹⁻²² Educational strategies that use example-based learning have not been widely applied to SBL. This study seeks to apply this principle to the design of the *brief* component of a SBL experience for novice health professional students. The planned study will add to the understanding of the example-based learning principle in two ways: its applicability to SBL and its effect on performance of verbal communication skills. Additionally, this study seeks to reveal more about how the *type* and *amount* of cognitive load experienced by novice health professional students during a simulation experience affects verbal communication performance.

Verbal communication between health care providers commonly follows a structured format or tool as a means to limit communication errors. The SBAR (Situation-Background-Assessment-Recommendation) tool was introduced in 2002 to assist in the communication of patient care information between providers.²³ Development of strong interprofessional communication skills is stated as being of paramount importance in fostering true collaborative practice for the 21st century.² A recent literature review indicates the SBAR format is effective in improving patient safety.¹⁹ Educators of future health professionals bear a responsibility to facilitate this development as effectively and efficiently as possible.^{1,2}

1.3 Research Questions, Hypotheses and Overall Aims

This study included three components. The first two involved collection of validity and reliability evidence for two measurement tools, the Leppink-Paas Scale²⁴ and the I-SBAR Communication Measure, planned for use in a third study component: a randomized

blinded controlled trial. The specific research questions and associated alternative hypotheses for the study are presented in Table 1.1. The initial component of the study was

Table 1.1 Research Questions and Associated Hypotheses

Research Question	Alternative Hypotheses
<p>RQ1: How does performance measured by an I-SBAR verbal communication tool compare between novice health care professional students who participate in a brief designed as a tutored problem vs. a traditional brief for a given simulation-based learning experience?</p>	<p>H1: Novice health care professional students who participate in a brief designed with a tutored problem will score higher on an I-SBAR verbal communication skill compared to peers who received a traditional brief for a given simulation-based learning experience.</p>
<p>RQ2: How does the type and amount of cognitive load reported by novice healthcare professional students compare between those who participate in a brief designed as a tutored problem vs. a traditional brief for a given simulation-based learning experience?</p>	<p>H1: Novice health care professional students who participate in a simulation brief designed with a tutored problem will experience lower levels of <i>extraneous</i> cognitive load compared to peers who participate in a traditional brief for a given simulation-based learning experience.</p>
	<p>H2: Novice health care professional students who participate in a simulation brief designed with a tutored problem will experience similar levels of <i>intrinsic</i> cognitive load compared to peers who participate in a traditional brief for a given simulation-based learning experience.</p>
<p>RQ3: What is the correlation between the self-reported types of cognitive load, and performance measured by an I-SBAR verbal communication tool for novice health care professional students who participate in a simulation brief designed as a tutored problem vs. participation in a traditional brief for a given simulation-based learning experience?</p>	<p>H1: There is an inverse relationship between level of self-reported <i>extraneous</i> load and score on an I-SBAR verbal handoff for novice healthcare professional learners.</p> <p>H2: There is an inverse relationship between level of self-reported <i>intrinsic</i> load and score on an I-SBAR verbal handoff for novice healthcare professional learners.</p>

RQ4:

How do novice healthcare professional students in simulation learning experiences interpret the wording of a survey instrument designed to differentiate between *intrinsic* and *extraneous* cognitive load?

designed as a qualitative cognitive interview. The goal of data collection and analysis links to research question 4 in establishment of response process validation evidence for the Leppink-Paas Scale, a tool intended to capture intrinsic and extraneous cognitive load experienced by learners. Results from the cognitive interviews were used to inform interpretation of results from the subsequent randomized trial. Additionally, these results provided insight into what factors contribute to intrinsic and extraneous load in a SBL activity.

The goal of the second component was to establish a “most reliable” rater to score all I-SBAR verbal performance data generated from the randomized trial. To this end, the second component established both the inter-rater and intra-rater reliability evidence across five raters on a tool designed to measure performance on verbal communication skills between healthcare providers (I-SBAR Communication Measure). These results link to research questions 1 and 3.

The third component of the study involved applying the CLT educational principles of the example-based learning and expertise reversal in a randomized blinded controlled trial involving novice health professional students. The *brief* component of a simulation experience acted as the independent variable to investigate the relationships between learner support, verbal communication performance, and cognitive load experienced by the learners. Data and analysis of this component linked to research questions 1,2 and 3.

The work had three specific overall aims:

1. to use CLT principles to guide the design of simulation experiences in health professional education to *optimize performance and learning outcomes*,
2. to measure cognitive load in simulation learning environments, and
3. to contribute to the understanding, through the use of simulation, of how best to assist development of health professional students who are ready for collaborative practice.

1.4 Definitions of Terms

This section serves to explicitly define common terms used throughout this dissertation to assist readers in their interpretation of this work. Many of these terms have myriad connotations and/or nuanced meanings when used in various settings. The terms below are defined as they will be used throughout this dissertation.

Pre-Brief: An orientation session held prior to the start of the simulation activity. The purpose of the pre-brief is to establish a psychologically safe environment for participants. Activities in a pre-brief include reviewing objectives, creating a ‘fiction contract’, and orienting participants to equipment, environment, manikin, roles, time allotment, and scenario.

Brief – Traditional (T brief): An information session immediately prior to simulation-based activity in which instructions or preparatory information about the simulation scenario is given to the participants. May include some components of the pre-brief above,

such as orienting participants to equipment, environment, manikin, roles, time allotment, and scenario.

Brief – Facilitated Tutored Problem (FTP brief): Includes all the components of a standard brief with the addition of a guided/facilitated reflection intended to (1) activate a participant's existing knowledge schema and (2) help develop problem-solving strategies for achieving the simulation activity learning objective(s).

Cognitive Interview: A qualitative interviewing procedure that attempts to collect verbal information about survey responses in order to evaluate the quality of the response to determine if the questions are generating the information the developer or user are intending.

Complexity/Complex (from a cognitive-load perspective): The number of separate information elements required to make sense of a task or situation: the greater the number of information elements included, the greater the complexity of the task or situation.

Context: Refers to a complex system that evolves over time. The resulting outcome is driven by interactions and feedback between elements in the environment (patient, provider, setting, and props within the setting); these interactions are not predictable and are therefore nonlinear in nature.

Facilitate: A process intended to make something easier. A process to assist the progress of a learner.

Fidelity (from a cognitive-load perspective): The degree to which the simulation replicates the real event. Fidelity is the ability of the simulation to reproduce the reactions, interactions, and responses of the real-world counterpart.

I-SBAR: A common communication tool used to minimize errors or omissions in the handoff of important information from one individual to another. Used extensively in health care settings as a framework for patient handoffs and reports between providers. **I** = introduction (providers name and profession), **S** = situation (purpose of the communication), **B** = background (brief summary of key events informing current handoff/report), **A** = assessment (report of objective data), **R** = recommendation/request (based on assessment statement of recommendation or request of receiving provider)

Novice health professional student: An entry level health professional student in a PT, OT, nursing, podiatric medicine, or physician assistant program who has completed basic science and communications courses and who has not more than 2 weeks of full-time experience as a student or licensed health professional in a true practice environment.

Schema/Chunking: A group of linked information elements that together can form a single information element. Schema formation or chunking occurs in long-term memory when information elements in working memory are processed and linked to existing information elements or schema. A highly complex schema can be treated as a single element in working memory.

Simulation activity: The component of a simulation experience in which the learner is immersed and interacting within the simulated environment. This is one component of a simulation experience.

Simulation experience: Encompasses the entirety of the simulation event inclusive of any specified prep-work prior to the activity, the orientation or pre-brief, brief, simulation activity, and debrief components (as well as any post-work after the simulation activity).

Support (from a cognitive-load perspective): The degree of instructional support provided to a learner. Example-based learning strategies of tutored or worked problems are the highest forms of support; partial completion tasks and autonomous task performance provide the lowest levels of support.

1.5 Summary

This introduction highlights the problem health profession educators face when designing simulation experiences for their students. SBL as an instructional tool, lacks a robust evidence base to guide educators in how best to structure simulation experiences to achieve and assess learning and performance outcomes. Leaders in the field believe a primary reason for this is a lack of simulation research grounded explicitly in contemporary educational theory.^{5,6,10} Explicitly grounding simulation research in contemporary educational theory allows for the prediction of outcomes and the testing of proposed hypotheses. The intent of this study is to apply the *cognitive load theory principles* of example-based learning and expertise reversal in the design of the *brief* component of a

simulation experience. The primary aim of this study is to determine if applying these principles affects performance outcomes on a verbal communication task possibly by creating a more cognitively optimal environment in terms of levels of ICL and ECL. It is hoped that directly comparing two differently designed simulation briefs using established educational theory principles will generate evidence that allows educators to predict performance outcomes for health professional students.

Chapter 2 Review of the Literature

2.0 Introduction

This chapter creates a context by providing a synthesis of the literature that led to the formation of the problem statements and research questions for this study. The review is organized into seven main sections. The first presents an historical overview of health professional education, followed by an overview of the need for interprofessional education. Next, the use of simulation in health professional education is discussed, including educational theory applied to learning from simulation. This is followed by a discussion of Cognitive Load Theory (CLT) and its application to health professional education, specifically simulation-based learning (SBL). The chapter closes with this studies intended contributions to the scholarship of teaching and learning (SoTL) related to SBL in the health professions.

2.1 Historical Overview of Health Professional Education

The early and mid-20th century were two periods of reform in health professional education. The first led to the doubling of life expectance globally, and the second to the inclusion of learning theory in health professions education creating alternatives to classic lecture-style learning in the health professions.^{2,25,26}

Despite the positive effects of these two waves of educational reform in the health professions, there remains a worldwide shortage of health professionals as identified in the World Health Report in 2006, "Working Together for Health."²⁷ This report implied that millions globally do not receive adequate health care despite the advances in educational practice.²⁷ In 2010, The Carnegie Foundation for the Advancement of Teaching marked the

100-year anniversary of the landmark Flexner Report publishing an updated review that focused on the state of medical education in North America. Findings identified continued problems in four areas noted as problematic 100 years prior (in the 1910 Carnegie Foundation Flexner Report).²⁶ Specifically, medical training continues to 1) be rigid and not learner centered, 2) lack in the transfer of didactic knowledge to experiential learning, 3) produce graduates who do not pay adequate attention to patient safety or the quality improvements needed in health care, and 4) produce graduates who lack an understanding of their expected civic and advocacy responsibilities to society.²⁶ A more expansive worldwide review of health professional education by The Independent Commission in 2010 - Health Professionals for the 21st Century - identified global systemic failure in sharing health care advances and an overall lack of readiness of health professionals' to anticipate and address new infectious, environmental, and behavioral risks that threaten the health of individuals and populations.²

These reviews argue that health professions education is in need of reform to improve the performance of existing health systems and move global population health forward. Strengthening “habits of the mind” to prevent complacency in practice and to bolster inquiry and quality improvement is a noted outcome of these reforms.²⁶ Additionally, creating an atmosphere for “transformative learning” concerned with the development of leadership skills in order to produce “enlightened change agents” is also important.² Habits of the mind and transformative learning address the same goal: that health professionals in the 21st century are educated to become the improvers and transformers of health care. The Independent Commission proposed a vision for these reforms: “Health professionals in all countries should be educated to mobilize knowledge

and to engage in critical reasoning and ethical conduct so they are competent to participate in patient and population centered health systems as members of locally responsive and globally connected teams.”²

The vision suggests that contemporary educational reforms focus on the training of health professionals to function as members of *transformational teams* foregoing the norm of siloed practitioners. Well-functioning transformational teams demonstrating quality collaborative practice require clear communication among team members. A primary aim of this study is to explore the *brief* component of a simulation experience as a possible educational tool to enhance the verbal communication skills between health providers. Specifically, can the brief act as a bridge to close the gap between didactic understanding and experiential demonstration of quality verbal communication skills? Additionally, can teaching strategies supported by Cognitive Load Theory assist in accomplishing this goal?

2.2 Interprofessional Education Facilitating Team-Based Collaborative Practice

In concert with the Independent Commission and Carnegie reviews, the World Health Organization (WHO) published a *Framework for Action on Interprofessional Education and Collaborative Practice*.²⁸ The document provides a framework for interprofessional education (IPE) in the training of health providers. The WHO defines IPE as education that occurs when students from two or more professions learn about, from, and with each other to enable effective collaboration and improve health outcomes.²⁸ It is understood that through IPE, *transformative learning* and *habits of the mind* are reinforced. According to the WHO, IPE is necessary in order to grow a collaborative practice-ready

healthcare workforce.²⁸ The definition of collaborative practice is multiple health professionals from different backgrounds providing comprehensive services by working with patients, families, care givers and communities to deliver the highest quality of care across settings.²⁸ The WHO proposed a series of IPE learning domains and associated outcomes, one of which is *inter-professional communication*.²⁸

In 2017, the Joint Commission reported that sentinel events continue to occur due to miscommunication among team members.²⁹ Clearly there is a need as health professional educators to ensure that graduates effectively achieve the IPEC core competency regarding intra-professional communication. Communication, as one of four competencies, was also adopted by the Interprofessional Education Collaborative (IPEC) in 2011. Revisions to these competencies occurred in 2016 and now include sub-competencies and language changes that more explicitly link to the collaborative practice ideas stated in the IPEC mission statement:³⁰

“IPEC, working in collaboration with academic institutions, will promote, encourage and support efforts to prepare future health professionals so that they enter the workforce ready for interprofessional collaborative practice that helps to ensure the health of individuals and populations.”

Table 2.1 illustrates the language for the IPEC Competency 3 – Interprofessional Communication, and the associated eight sub-competencies. Sub-competencies CC1, CC2, CC3, and CC6 (in bold below) were used in formulating learning objectives (Appendix 1) for the simulation experience associated with this study.

Table 2.1: 2016 IPEC Core Competency 3: Interprofessional Communication and sub-competencies

Competency 3 (Interprofessional Communication)	Communicate with patients, families, communities, and professionals in health and other fields in a responsive and responsible manner that supports a team approach to the promotion and maintenance of health and the prevention and treatment of disease.
Sub-competencies	
CC1	Choose effective communication tools and techniques, including information systems and communication technologies, to facilitate discussions and interactions that enhance team function.
CC2	Communicate information with patients, families, community members, and health team members in a form that is understandable, avoiding discipline-specific terminology when possible.
CC3	Express one's knowledge and opinions to team members involved in patient care and population health improvement with confidence, clarity, and respect, working to ensure common understanding of information, treatment, care decisions, and population health programs and policies.
CC4	Listen actively and encourage ideas and opinions of other team members.
CC5	Give timely, sensitive, instructive feedback to others about their performance on the team, responding respectfully as a team member to feedback from others.
CC6	Use respectful language appropriate for a given difficult situation, crucial conversation, or conflict.
CC7	Recognize how one's uniqueness (experience level, expertise, culture, power, and hierarchy within the health team) contributes to effective communication, conflict resolution, and positive interprofessional working relationships.
CC8	Communicate the importance of teamwork in patient-centered care and population health programs and policies.

The competency encompasses effectively using communication tools to share information that is understandable by health team members in a respectful manner that clearly expresses one's knowledge and opinions.³⁰ One barrier to effective and efficient communication in health care has been identified as the lack of a standardized structure.^{31,32} Studies have demonstrated that integrating the SBAR tool into clinical practice leads to improved quality and patient outcomes, improvements in the climate of safety, and reduces incident reports due to communications errors.³³⁻³⁵ A recent literature

review concluded that simulation and the use of standardized tools such as SBAR have been successful in improving communication skills in health professional students.³⁶ The review recommends that faculty evaluate learners' communication performance in simulation with valid and reliable instruments.³⁶ Findings from this research suggest that *how* a simulation experience is designed directly effects that performance.

Transforming and Scaling up Health Professionals' Education and Training: World Health Organization Guidelines 2013 calls for "the sustainable expansion and reform of health professionals' education and training [so as] to increase the quantity, quality and relevance of health professionals [in order to] strengthen the country health systems and improve population health outcomes."¹ The guidelines provide recommendations for several contemporary teaching and learning strategies based on the overall quality of supporting educational evidence. The WHO Guidelines present a summary of the evidence in favor of IPE as a recommended educational strategy, but they label the recommendation *conditional*. The conditional label is in response to the overall low-grade quality of evidence demonstrating confidence in health professionals' self-identity, appreciation of the roles of other professions, and improvement in communication and teamwork skills important for collaborative practice.¹ In contrast, the use of simulation as an educational strategy to promote collaborative practice is given a *strong* recommendation, despite the evidence receiving a grade of moderate quality. The WHO guidelines note that a *strong* recommendation for simulation as an educational strategy is warranted because of the potentially far-reaching impact of simulation on the quality and relevance in training the future and current health professional workforce.¹ This discrepancy between the quality of the current body of evidence and the strength of recommendation for using simulation as

an educational modality to achieve outcomes consistent with the IPEC core competencies provides a critical opportunity for health professional educational researchers to work toward closing the gap through the generation of high quality evidence.

Disrupting the status quo in health professional education is intended to create transformational learners with habits of the mind to challenge the current state of health care across the globe. Two promising educational strategies are suggested to create the reality of true collaborative practice: expanding the role of simulation and focusing on interprofessional education. Simulation has the potential to facilitate informative, formative, and transformative learning.² Additionally, simulation experiences may accelerate learning.¹ Both the Independent Commission and the World Health Organization recommend using simulation as a modality to facilitate the goal of collaborative practice.^{2,28} Despite these recommendations, the quality of evidence guiding educators in how to most effectively use simulation to its fullest potential is limited. Increasing the amount and quality of evidence is a strongly suggested focus of health professional educational researchers worldwide and is discussed further in section 2.3.3.

2.3 Simulation in Health Professions Education

2.3.1 History of Simulation Based Health Education

The use of simulation as an adjunct to the clinical training of health providers has a longstanding history. A Sanskrit text written between the 4th-6th centuries BC describes making life-sized whole body simulators for the purposes of practicing medical and surgical skills and procedures.³⁷ In 10th century China, life-sized bronze statues were used to teach acupuncture skills.³⁷ Midwives and surgeons in 18th century Europe used

“birthing” simulators to practice procedural skills as well as train students.³⁷ In the mid-20th century, Åsmund Lærdal developed “Resusci-Anne”, creating a low-cost effective training model that opened the door for the ongoing development of ever more sophisticated human simulators.³⁸

Technological advances have provided the ability to create realistic human physiological processes and disease states through fabrication of more advanced simulators and computer programs. These advances together with using of higher fidelity forms of simulation, have led to growth in the use of simulation as a teaching modality in health professional education.³⁹ What is lacking is clear understanding of how best to use simulation modalities to enhance and optimize learning in health professional education.^{5,40,41}

2.3.2 Evidence for Simulation-Based Learning in Health Education

The evidence base identifying best practices supporting the use of simulation-based learning (SBL) in health education is minimal.^{7,42} To date, only four systematic reviews concerned with identifying instructional design practices that optimize learning of health professional students through SBL have been published. All conclude that, despite improvements in the methodological quality of included studies over the years, the overall quality standard for educational research in this area remains a concern. The initial systematic review, published in 2005, was *qualitative* in nature, and included literature from 1969-2003.¹¹ The remaining three reviews (published by the same author group) were *quantitative* systematic reviews covering the literature through May 2011.³⁻⁵

The authors of the qualitative review addressed the question “what are the features and uses of high-fidelity medical simulations that lead to most effective learning?”¹¹ They

defined a high-fidelity simulator as one that changes and responds to the user, as opposed to a simulator that remains static. To ensure quality in their process and reporting, the authors were transparent in following prior work delineating the elements required of a high-quality literature systematic review. Their literature search spanned five databases resulting in 109 articles included in the final review. Despite reporting that approximately 80% of the published findings in these articles were open to more than one interpretation, the authors concluded that high-fidelity medical simulation does facilitate learning.¹¹ Ten features of simulation design were identified as encompassing the “right conditions” to facilitate learning. They are in order of descending importance; feedback, repetitive deliberate practice, curriculum integration, range of difficulty, multiple learning strategies, clinical variation, controlled environment, individualized learning, defined outcomes and simulator validity or realism.¹¹

It is important to note from this review that the majority of early simulation literature is concerned primarily with skill acquisition and procedural training; this may provide context as to why repetitive deliberate practice emerged as one of the top learning conditions. Additionally, live or standardized patients (SPs) were not included nor defined in this review as a high-fidelity modality. The authors identified conditions that best facilitate learning from high-fidelity simulation that cannot be applied when using SPs. Since the publication of this review, the field of simulation has specifically defined *high-fidelity simulation* as “simulation experiences that are extremely realistic and provide a high level of interactivity and realism for the learner. It can apply to any mode or method of simulation; for example: human, manikin, task trainer, or virtual reality.”⁴³ The use of SPs as a simulation modality today would be considered to be a high-fidelity simulation.

The first of three quantitative systematic reviews and meta-analyses was published in 2011 and adheres to the PRISMA standards for quality reporting. This review sought to answer two questions: 1) To what extent is technology enhanced simulation training for health professionals associated with improved outcomes in comparison to *no intervention*? and 2) How do outcomes vary for different simulation instructional designs?³ The authors define technology-enhanced simulation as encompassing computer-based virtual reality simulators, high-fidelity and static mannequins, plastic models, live animals, inert animal products, and human cadavers.³ Similar to the 2005 review, standardized patients were not included as a simulation modality. The authors used broad criteria to include studies in any language, health professional learners at any stage in training and practice, any research designs that compared simulation to no other instruction, and no earliest cutoff date for inclusion. The search resulted in 609 studies included in the final analysis and spanned publication from 1969 through May 2011.

In comparison to no intervention, technology-enhanced simulation in the training of health professionals is associated with *large* positive effects for knowledge, skills and behavior outcomes and *moderate* effects for patient related outcomes.³ The authors point to continued problems with study quality but argue that because of the large established effect sizes across multiple learning outcomes, future researchers need not be concerned with comparisons of simulation to no intervention.³ Additionally, because this review did not compare simulation to any other educational intervention, the authors completed a follow-up review addressing this limitation.

The second quantitative review in 2012 addressed the following questions: 1) What is the effectiveness of simulation technologies for training health professionals in

comparison with *other instructional modalities?* and 2) How do outcomes vary for selected instructional design variations?⁴ Again, the authors adhered to the PRISMA standards for reporting. They defined technology-enhanced simulation in a similar manner to their initial 2011 review and were explicit in stating that the current review included health professional learners at *any* stage in their training or practice.⁴ Using a similar broad search strategy (and eliminating studies that did not explicitly compare simulation with a different instructional modality), 92 studies were included in the final review. Of note is that standardized patients were explicitly included as one of the comparison instructional modalities.

Results demonstrated that technology-enhanced simulation training, in comparison with other instructional modalities, is associated with higher learning outcomes. Pooled effect sizes were small to moderate for most outcomes, and differences were statistically significant for student satisfaction, knowledge, and process skills.⁴ The authors note that standardized patients and real patients had effects similar to technology-enhanced simulation for all outcomes except process skills. Additionally, lecture, small-group discussion, and video training (all less expensive forms of instruction) were noted as inferior to technology-enhanced simulation on learning outcomes.⁴

The third quantitative review was published in 2013 with the specific intent to include studies with head-to-head comparisons of different simulation instructional interventions.⁵ The questions addressed were: 1) what instructional design features are associated with improved outcomes in studies directly comparing one technology-enhanced simulation training approach with another? and 2) what themes have been addressed in such comparisons?⁵ Reporting standards and broad search strategies, similar

to those employed in the previous two reviews, resulted in 289 studies included in the review with a total of 18,971 subjects.⁵ The authors selected eight instructional design features (“right conditions”) identified in the 2005 review and added the following as additional comparisons: added cognitive interactivity, distributing training across multiple sessions, group vs independent practice, and time spent learning as additional comparisons. Based on small pooled effect sizes, they identify the following ‘best practices’ for simulation instruction in descending order of importance; provide a range of difficulties, repetitive practice, distributed practice, cognitive interactivity, multiple learning strategies, individualized learning, mastery learning, feedback, longer time for learning, and clinical variation.⁵ The authors argue that simulation research needs to go beyond simple comparisons of the presence or absence of key design features. They argue that simulation research is at point where studies designed to manipulate how each of the identified design features is applied are needed to truly identify best practices. Specifically, they note that feedback appears to strongly improve outcomes; however, the field lacks an understanding regarding the best timing and delivery of feedback.⁵

The number of studies identified in the 2013 review that attempt to clarify the best use of simulation through direct comparison of different simulation-based interventions is small at 289.⁵ One would anticipate the number of studies that specifically manipulate a single simulation-based intervention to be even smaller. The primary goal of this dissertation is to manipulate the best practices of *feedback* and *cognitive interactivity* by applying principles derived from Cognitive Load Theory to simulation design. The aim is twofold: to understand how providing feedback, in the form of a tutored problem, during the brief component of a simulation affects performance on communication skills and to

measure how that feedback affects cognitive interactivity as opposed to not providing this type of feedback. The development of effective communication skills is particularly important; miscommunication has been identified as far back as the publication of *To Err is Human* in 1999 as the greatest source of error in health care delivery.⁴⁴

2.3.3 Expanding Avenues for Feedback and Reflection in SBL

Evidence exploring learning from simulation has been directed toward feedback in the form of the debrief as the key design variable.^{7,45} The debrief component of a simulation experience is linked to learning through the ideas of Reflective Practice, developed by Schön.⁴⁶ Schön challenged the view that professional practice in health science was similar to that of applied science; he argued that, unlike applied science, those practicing in the health sciences are not generally presented with an identified problem. Furthermore, once the problem has been identified, solutions are not fixed, clear or agreed upon.^{47,48} This presents the challenge of finding solutions within situations in health sciences practice filled with uncertainty, instability, uniqueness, and value conflict. To address these issues, Schön proposed that reflection-on-action would facilitate the type of learning required in health sciences practice.⁴⁸ Reflection-on-action in the form of debriefing activities has been the key strategy for providing feedback from simulation experiences to learners. Several guides provide useful summaries of best practice strategies for maximizing the learning impact of feedback received during debriefing activities.^{7,45} Although the idea of *reflection-before-action* is often attributed to Schön, his work largely ignored this concept, instead focusing on “virtual world[s] relatively free of the pressures, distractions and risks of the real one”, where coaches “get into the action” with students and use reflection *in* and *on* action to facilitate learning.⁴⁸ Greenwood argued

that real-world practice is full of pressures, distractions, and risks, and that students may be inadequately prepared when “real” situations are encountered.⁴⁹ Greenwood was the first to suggest the concept of reflection-before-action as a possible solution to this dilemma. Reflection-before-action is thought to move a student from a state of undifferentiated awareness to one of conscious appreciation of the potential situation about to be experienced. This process allows for the analysis of the situation prior to it taking place and potentially enriches learning and practice development while relieving anxiety.⁵⁰ This type of process can be thought of as an attempt to bring a learner’s “knowledge in pieces” together.⁵¹ Greenwood suggested that the prior work by Schön on reflection undervalued the potential contribution of reflection-before-action in facilitating learning.⁴⁹ There appears to be very little reference to the concept of reflection-before-action in the literature from the time of Greenwood’s publication in 1993. In 2017 Edwards commented that the notion of reflection-on-action helping to develop reflection-in-action for clinical practice is not yet demonstrated in the literature.⁵⁰ Edwards suggests a broader approach to reflection is needed in facilitating professional development; this approach should include the two additional dimensions of reflection-for [before]-action and reflection-beyond-action.⁵⁰

2.3.4 Recommendations in Health Professions Educational Research for SBL

There is a longstanding debate in the field of educational psychology that began with Richard Clark arguing that the medium through which instruction is delivered will never influence learning. Clark noted that media are “mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers groceries causes changes in our nutrition.”⁵² According to Clark, what influences learning are the

instructional methods underling the use of the medium or technology.⁵³ Kozma challenged Clark's argument suggesting a synergy between instructional medium, content of the learning activity and the environment all interact with the learner.⁵⁴ Despite these differing views there remains no conclusive evidence to suggest any one instructional technology is more effective than any other.⁵⁵ Cobb suggests it is most likely that there is always more than one educational medium an educator can use to obtain the same *direct* learning outcomes; however it may be that different educational tools have different *effects* on direct learning.⁵⁶

Cobb posits a revised theory on learning and media that focuses on exploring "cognitive efficiency", linking media choices in instruction to ease of learning specific content by lessening "cognitive load".⁵⁶ Joy goes further by suggesting research questions be directed at exploring "what combination of instructional strategies and delivery media will best produce the desired learning outcome for the intended audience?"⁵⁷ Although the preceding discussion concerns itself with internet and computer instructional mediums, the ideas apply to simulation as an instructional medium as well. The argument has been made that if there are no learning differences in outcomes between different levels of fidelity used in simulation, then educators must choose the least expensive option.⁴¹ As some have stated, "like any other tool, the effectiveness of simulation technology depends on how it's used".⁵⁸

Bradley posits that without a commitment to creating a strong evidence base, simulation at best will retain a peripheral place in the education and training of health professionals. The worst outcome is that simulation will stagnate for the lack of forceful argument in its favor.³⁸ As healthcare simulation scholarship matures, so do the questions

about how best to advance the science of simulation.⁵⁹ Specifically, educators have called for research directed at simulation instructional design in order to identify what works, for whom, and under what circumstances.⁵⁻⁷ Adamson goes further, echoing many in the simulation educational community by asking, “what are ‘good’ educational practices in simulation and is it simulation or other educational practices that make simulation effective?”⁶⁰ Artino and Durning ask “what are the key factors and instructional methods used with simulation that positively influence learning and transfer?”⁹ They define transfer as: the ability to extend what has been learned in one context to new contexts. This ability to transfer is linked to the development of expertise.⁹ Instructional design research has been viewed by key constituencies as a top priority for scholarship in health professional simulation.^{6,61}

Others suggest the efforts of simulation research need to move away from a focus on procedural skills training and toward clarifying effective simulation strategies to enhance patient safety and quality improvement across healthcare settings.⁶² Pucher et al.⁶² echoes the goal of using simulation as a modality to train transformative learners with habits of the mind ready for collaborative practice. This goal has been supported by the Independent Commission and the Carnegie Foundation as strongly needed in the 21st century healthcare environment.^{2,26}

Incorporating the use of learning theories and conceptual frameworks into simulation research is also strongly recommended.⁵ Doing so will make clear the links and mechanisms underlying instructional design interventions, as well as improve the ability to generalize study findings.⁵ “How do theories of learning and teaching inform the design of simulation interventions?” and “How do theories of cognitive load inform the design and

structure of simulation programs, courses, and concrete scenarios (based on the complexity of tasks required for learners to acquire and maintain)?" are two questions put forth as part of a comprehensive research agenda for SBL in the health professions.⁶

Grounding educational research in theoretical frameworks allows researchers to state predictions for outcomes as well as set limits for generalizing findings in the context of the stated framework.

2.3.5 Synthesis

Simulation-based learning in health professional education has become an integral component in the training of health professionals. Recommendations urge educational researchers to begin to contribute *quality* evidence, beyond answering the question of whether simulation as an educational modality works. There is a need to understand why, how, and for whom simulation education works. Studies grounded in educational theory are of paramount importance as they then allow for hypothesis generation and prediction of outcome elucidating best practices in SBL. This study is grounded in Cognitive Load Theory, discussed in detail in section 2.5. The theory provides:

- a framework for viewing the *brief* component of a simulation experience as
- an avenue to provide "feedback" through
- a guided reflection-before-action facilitated tutored problem activity.

It is hypothesized that applying principles derived from this theory the cognitive engagement of the learner is optimized in a way that allows for analysis of the situation prior to it taking place. Facilitating a learner-generated roadmap to achieving simulation-experience learning objectives may aid novice health professional learners in achieving improved performance outcomes.

2.4 Educational Theory in Simulation Based Learning

Theory provides a framework for understanding and exploring ideas. Theories are not static but intended to be complex and contestable. They are, as Nestel et al.⁶³ describes, simply a sequence of ideas. The study of simulation in health professions education has been grounded by educational learning theories most commonly evolved from the constructivist perspective. *Constructivism* refers to the idea that learners construct knowledge for themselves, each learner individually constructing meaning as he or she learns. Constructivism is learner-centered and aims to understand how people create different versions of reality.⁶⁴ Many foundational learning theories fall under the umbrella of constructivism. Kolb's experiential learning,^{65,66} Brown's situated cognition and cognitive apprenticeship,⁶⁷ Knowles' adult learning theory,⁶⁸ and Vygotsky's zone of proximal development from socio-cultural learning theory⁶⁹ each provide an example of constructivism historically linked and applied to simulation-based learning.

More recently the cognitivist perspective has surfaced as a lens to view health professional medical education.^{18,70-72} The cognitivist perspective attempts to understand a learner's thought process. Cognitive Load Theory falls under the cognitivist umbrella and has recently been applied to simulation-based learning in the nursing and pharmacy literature.^{12,13,73} Cognitive Load Theory is described in detail in section 2.5 and provides the grounding theoretical framework of this dissertation.

Despite the historical grounding of simulation-based learning in health professional education in constructivist learning theories, Kneebone argues that developing "a 'theory of simulation' is key to establishing a science which allows us to formulate and test hypotheses, engaging critically with an evidence base that transcends the accumulation of

nuggets of knowledge.”⁷⁴ As Issenberg et al.⁶ state, “learning theories have been helpful to guide researchers working on simulation in providing a framework... simulation has thus provided an opportune environment to apply these established theories in new conditions and contexts. However, simulation can also provide a controlled environmental setting to develop and test new theories or challenge old assumptions about how people learn.”

Constructivist learning theories promote learning in realistic environments to provide needed context from which to ground new understanding. A cognitivist perspective adds that if learners are immersed in realistic environments without consideration for the potential cognitive overload of working memory, any potential for constructing meaning becomes increasingly difficult or impossible. A layered approach to realism through the use of simulation provides an avenue upon which strategies to optimally titrate cognitive load can be applied and controlled through a learner’s professional development.

2.5 Cognitive Load Theory

Cognitive Load Theory is concerned with how information made available during instruction interacts with human cognition during the process of learning.¹⁵ It emphasizes that the primary determinant of effective instructional design is working memory (WM) constraints.^{15,16} The theory assumes that performance and learning are impaired when the cognitive demands associated with a learning activity exceed a learner’s limited WM capacity. This state of exceeding a learner’s WM capacity is termed cognitive overload.^{15,17,18}

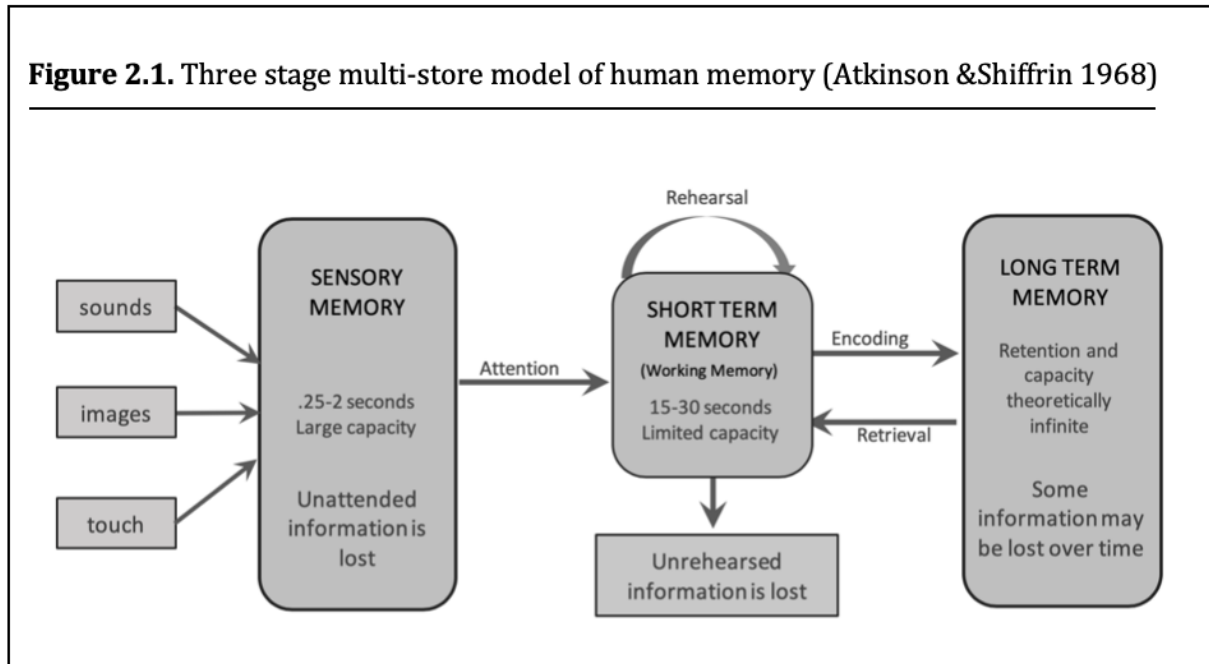
2.5.1 Foundations

Cognitive Load Theory (CLT) was proposed by John Swell in 1988 and has emerged as a dominant educational theoretical framework for health professional educational research.^{8,18,70} CLT builds on established models of human memory first developed by Atkinson & Shiffrin in the late 1960s.⁷⁵ Their 3-stage multistore model of human memory established a relationship between memory sub-systems: sensory memory (SM), short term or working memory (WM) and long-term memory (LTM) (Figure 2.1). Additionally, the multistore model represented WM as having limited storage capacity (unlike that of sensory and long-term memory where capacity is thought to be limitless). The multistore model serves as a useful overview of how information is processed and stored in human memory. The multistore and capacity concepts together define human cognitive architecture. CLT builds on this model of cognitive architecture by providing a framework for understanding the limits in working memory capacity, specifically in regard to the types of information processing needed to promote learning.^{76,17} The theory emphasizes that WM constraints are the primary determinant of instructional design effectiveness.^{15,16} In summary, once the working memory capacity of an individual is 'overloaded' by the differing cognitive processing demands of an educational activity, learning cannot occur.^{15,17}

2.5.2 The Multistore Model of Human Memory

The multistore model (Figure 2.1) posits that memory formation begins when visual, auditory, or haptic information from the environment is detected. While the capacity of sensory memory (SM) to receive sensory stimuli is unlimited, the data are only retained for a short period of time (from 0.25-2 seconds).⁷⁷ An individual does not become aware of the

data or information in SM unless they consciously attend to the information. In this way, human attention acts as a filter in the learning process.¹⁷



Attending to information in SM brings that information to an individual's consciousness. When this occurs, the information has moved into working memory (WM). Most data received in SM does not rise to conscious awareness which can lead to what Simons labeled *inattentional blindness*.⁷⁸ This phenomenon was illustrated in a classic study involving participants who were instructed to focus on counting the number of basketballs passed between players in a game. While doing so, the players completely missed "seeing" a man in a gorilla costume walking through the game.⁷⁸ Once in WM, information is organized and packaged for encoding (storage) in LTM. This process involves the retrieval of relevant LTM schema into working memory. The retrieved schema is then adapted with new understanding and encoded back into LTM. LTM, through this adaptive schema process, is thought to have a limitless capacity in terms of how long (duration) and how much (volume) information can be accommodated. Young et al.⁷⁹

describes the capacities of LTM as an ever-expanding route map, built of meaningful connections, to facilitate finding information needed in the future.

2.5.3 Working Memory (WM)

Unlike LTM and SM, working memory (WM) holds information in a state that is accessible to human consciousness, which allows it to be actively manipulated.¹⁵ Working memory provides the interface between perception, LTM, and action. It supports a range of cognitive activities, including analytic procedures, reasoning, comprehension, and learning.⁸⁰

Limited in both storage capacity and ability to retain information over time, WM is often described as the “bottleneck” of the memory system. WM can hold onto only 5-7 “chunks” or information elements at one time and, if not rehearsed within 15-20 seconds, the information element disappears from WM storage.^{81,82} Additionally, WM can only manipulate or work with 2-4 information elements at once, already the upper limits of human active processing capacity.⁸³ Both of these characteristics of working memory adversely affect learning, as exceeding these limits decreases the effectiveness of active processing.¹⁵ What CLT attempts to address is how to best optimize “load” on WM in order to promote learning; doing so maximizes a learner’s active processing potential. This leads to the integration of new information with existing related knowledge organized and stored in LTM. Additionally, when WM capacity is severely taxed, a learner’s ability to acquire new knowledge and store information in a manner that they can transfer to new situations is decreased.⁸⁴ The ability to generalize or transfer knowledge to novel situations has been linked to the development of expertise.⁹

2.5.4 Types of Cognitive Load Imposed on Working Memory

A tenet of CLT is that there exist different types of load or cognitive processing imposed on the limited WM resources. The first of these is *Intrinsic Cognitive Load (ICL)* or cognitive resources that are devoted to dealing with the inherent complexity of the learning environment, task or problem. Complexity as defined here is the number of information elements that must be considered simultaneously (element-interactivity) in order for a learner to make sense of the activity.⁸⁵ ICL for a learning activity cannot be altered by instructional design or methods; it is inherent to the activity or problem at hand.¹⁴ Managing ICL directly can only be accomplished by changing the learning activity itself; ICL can be managed by designing a learning activity that is not too challenging or too easy (to avoid overloading WM capacity or reducing motivation and interest). Because ICL for a given learning activity varies depending upon the level of experience a learner has in a particular domain of understanding,^{14,85} Altering the number of interacting elements that must be processed simultaneously can reduce WM overloads for a less experienced learner. Conversely, a learner entering into the activity with a more developed expertise in that learning domain should require fewer interacting elements be processed simultaneously in WM during a learning activity.¹⁵⁻¹⁷

As an example, a novice learner in the health professions having only a didactic understanding of vital signs, electrocardiogram (ECG) dysrhythmias and limited clinical exposure may be asked to determine the stability of a patient. In a simulated environment, with a standardized patient asking questions and physiological monitors displaying vital signs and ECG rhythms, the learner would experience very high ICL. This situation would most likely overload a novice's WM capacity and potentially diminish learning. Decreasing the element complexity of the learning activity by substituting a non-interactive manikin

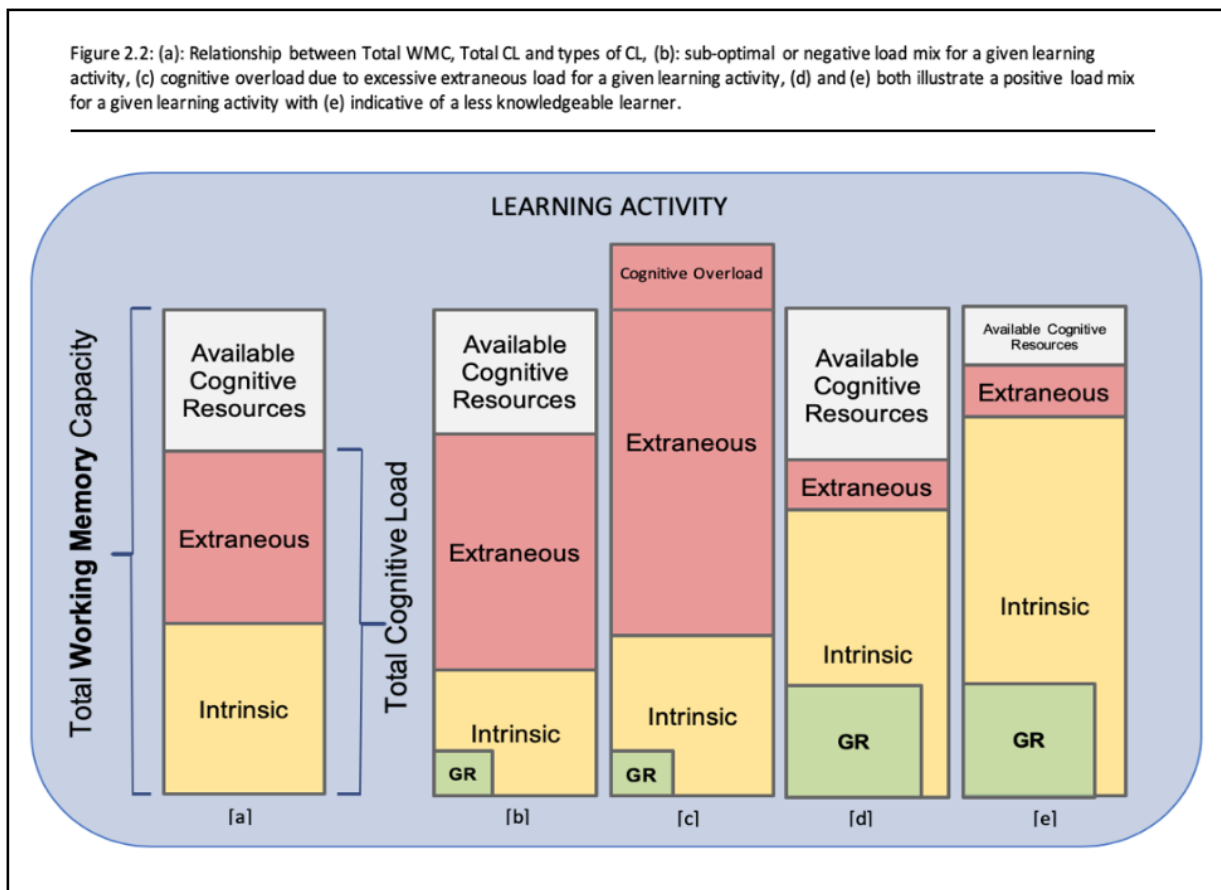
for the standardized patient would reduce the ICL for the activity. The learner in this case would not be concerned with conversing or answering questions posed by the patient. The learner must consider fewer interacting elements, potentially improving the match between the learner's level of experience/expertise and the learning activity.

The second category of load is *Extraneous Cognitive Load (ECL)* defined as resources devoted to understanding the manner in which a learning environment, task, or problem is presented. Extraneous cognitive load (ECL) refers to the WM resources taken up by cognitive processing that is not essential to the learning activity. ECL can increase because of inefficient instructional design. To mitigate the detrimental effects of ECL on learning, element interactivity unrelated to the goals of instruction should be controlled.^{16,85} ECL can be altered, ideally lowered, through intentional instructional design strategies.^{14,85} In using the above example for the learner with limited clinical exposure, when asked to determine the stability of a patient, eliminating unnecessary equipment and sounds from the environment would decrease ECL. Doing so may free up WM resources to create new understanding.

The third and last category of load is termed *Germane Cognitive Load (GCL)* or *Germane Resources (GR)* and is associated with the WM resources needed in creating new knowledge and/or revising existing knowledge.^{14,15,85,86} There is some controversy regarding whether GCL is an independent type of load. Recent discussions contend GCL is a specific feature of the learning activity and therefore a part of ICL.⁸⁶ From this perspective GCL is referred to as germane resources (GR); however, regardless if indistinguishable from intrinsic cognitive load, GR or GCL reflects the WM resources invested in learning.

2.5.5 Relationship Between Total Working Memory Capacity, Total CL, and Types of CL

Cognitive Load Theory views the types of load as additive and all three (intrinsic, extraneous, and germane resources) are inherent in some capacity in all learning activities.¹⁸ The effect of increasing one type of load depends on the load imposed by the other types, relative to a learner's experience. In Figure 2.2 several different cognitive load mix variations are represented as columns for a given learning activity (represented by the blue surrounding).



Column (a) represents *Total working memory capacity* which is comprised of the three types of cognitive load (germane, intrinsic, and extraneous) that make up *total cognitive load* plus any remaining *unused available cognitive resource*. A sub-optimal or potentially negative learning activity is an activity with too much extraneous load and not enough

complexity (element interactivity) for a given learner. Extraneous load might be anything from background music playing during a simulation to a learner being aware of and distracted by associations the learner may have with the examination tools used in a particular activity. In any case, extraneous load takes attention away from the learning goal at hand, which may result in limited resources being devoted to learning (GR) as represented in columns (b and c). In cases where there is excessive extraneous load (too much distraction as in column c) or excessive intrinsic load (too difficult a challenge), cognitive overload may result. Positive learning activities incorporate optimal complexity (or element interactivity) while limiting extraneous load levels, resulting in a fairly high level of working memory resources being used as germane resources. Columns (d) and (e) both represent positive load mixes with (e) representing a load mix for a less knowledgeable learner.

2.6 Cognitive Load Effects – Instructional Applications

From the initial conception of cognitive load theory 40 years ago to its present conceptualization, the over-riding goal has been to provide a framework that allows for the generation of novel instructional principals. This study considers two of these principles; example-based learning and the expertise reversal. Both are reviewed in more detail with a summary of the literature supporting their use in this study.

2.6.1 Example-Based Learning - Worked Problems and Tutored Problems

Example-based learning includes learning through the study of worked problems or through step-by-step guidance by tutors and has a robust evidence base indicating the strategy is effective in facilitating understanding for novice learners in a knowledge

domain.^{19,87} Compared to conventional problem-solving strategies, example-based learning strategies appear to reduce extraneous load, allowing a learner to devote available WM capacity to studying an already completed solution or a facilitated solution; the learner thereby constructs schema in LTM for solving similar problems in the future.^{19,87,88} The advantages of example-based learning over conventional problem solving is known as the 'worked example effect'.¹⁹

Sweller et al.¹⁵ hypothesize the effectiveness of example-based learning through a CLT perspective is what occurs when learners unfamiliar with a knowledge domain are confronted with a problem and then respond by engaging in means-end-analysis or goal-based problem solving. This approach to problem solving puts high demands on the limited capacity of the novice learner's working memory and normally does *not* lead to the creation of new knowledge or development of problem-solving schema. In contrast, providing worked examples or tutored examples was hypothesized to limit learners from engaging in irrelevant cognitive search processes. Limiting irrelevant cognitive searching frees WM resources that can then be used to engage in understanding the solution. Example-based learning, by creating a lower demand on WM resources, is thought to support the construction of problem-solving schemata in LTM for novice learners.¹⁵ Van Gog et al.¹⁹ published a 2010 review of selected studies on example-based learning conducted from a cognitive and social-cognitive perspective. The review illustrates that for novices worked example instruction is more effective and efficient for learning ,and deeper learning is achieved with less time and mental effort compared to instruction consisting solely of problem solving.¹⁹ Also noted is that worked example instruction as a teaching

strategy varies widely limiting the ability to make definitive conclusions regarding best practices in using example-based learning.¹⁹

In a follow-up to study addressing the concerns generated from the 2010 review, Van Gog et al.⁸⁹ compared three example-based problem-solving strategies to problem-solving only in a group of 103 secondary students who were novices in troubleshooting electrical circuit problems. The students were randomly assigned one of four groups:

1. studying worked examples only (WE)
2. problem solving only (PS)
3. problem solving followed by studying worked examples (PS/WE)
4. studying worked examples followed by problem solving (WE/PS).

Results showed that PS and PS/WE conditions were less effective than WE and WE/PS conditions. The WE and WE/PS groups significantly outperformed the PS and PS/WE groups on post-test knowledge. Additionally, higher post-test performance scores were associated with lower investments of mental effort scored on the Paas Scale (discussed in section 2.7). Additionally, the criticism that example-based learning is beneficial over problem solving only because example-based learners received more information and instruction time was challenged in this study. The WE/PS group outperformed the PS/WE group despite both groups receiving exactly the same information and instruction time. They differed only in the order the strategies were experienced. In summary, the results show that substituting some of practice problems with worked examples is not necessarily always effective. The effectiveness depends on when the worked examples are provided: before or after problem solving. This study demonstrates that worked examples are most effective when provided to novice learners *before* problem solving. This finding fits with

Sweller's CLT view that worked examples facilitate novice students in building cognitive schemas that can guide future problem solving.¹⁵

Van Gog et al.⁹⁰ suggest that worked examples may not be effective in supporting the acquisition of flexible or transferable knowledge because worked examples are typically quite structured: they consist of a problem, solution steps, and a final solution. Process-oriented information about *why* specific solution steps are used (the rationale behind the problem) or *how* one selects appropriate knowledge (strategic knowledge) to solve the problem is not provided in classic worked problem examples.⁹⁰ To optimize learning from worked examples, Van Gog et al.⁹⁰ suggest written or video recorded instructional explanations with process-oriented information added to worked examples. A meta-analytic review by Wittwer et al.⁹¹ concluded that adding written process-oriented instructional explanations to worked examples had a significant, but small, positive effect on learning. Additionally, adding process-oriented explanations (rationales) was more helpful for acquiring conceptual rather than procedural knowledge, and was equally effective in prompting students to provide self-explanations.⁹¹

Salden et al.⁹² explored tutored problem solving through computer-generated assist as a means to maximize self-explanation opportunities in learners (a strategy not possible in classic worked example studies). The authors reviewed eight studies in the domain of mathematics comparing computer generated hints in response to student errors to planned computer generated step-by step problem solving with explanations and questions (tutored problem). The proposed conclusion from this review is that tutors reduced extraneous cognitive load by limiting the cognitive solution space students have to search, and in response increased generative processing by guiding students through the

solution space.⁹² In effect, tutored problems are hypothesized to decrease the amount of wasted cognitive searching for answers, and in this way are similar to the benefits of worked problems. However, tutored problems have the added effect that they promote the acquisition of flexible or transferable knowledge due to prompting for self-explanations and reflection of process.⁹²

In summary, example-based learning in the form of worked examples is most effective when provided to novice learners *before* problem solving. When supplemented with process-oriented explanations and strategies that prompt learners toward self-explanations and reflection, example-based learning in the form of tutored problems is hypothesized to lead to the acquisition of flexible and transferable knowledge in novice learners.⁸⁹⁻⁹² To date, example-based learning has been applied in pen-to-paper written problem formats, as well as tutored problems through interactions with computer programs. What is not known is whether example-based learning translates to improved learning from simulation experiences. Specifically explored in this study was whether or not the *brief* component of a simulation experience can act as the container for a process-oriented tutored problem where learners are facilitated in a reflection-before-action activity as discussed in section.

2.6.2 Expertise Reversal Effect

The expertise reversal effect was first discussed in the context of CLT in 2003 by Kalyuga et al.²¹ The effect is based on the idea that a learner's level of understanding or knowledge in a specific area/task is critical in determining the components of a learning activity to which a learner allocates their WM resources. As a learner's expertise develops, the information in a learning activity deemed relevant to WM changes for a given learning

outcome.²¹ Experienced learners in an area of knowledge have developed complex accurate mental schema made up of many interconnected information elements. Complex mental schemas are stored in LTM as single information elements or chunks. Given that the WM of most individuals can only actively work with 2-3 chunks of information at one time, an experienced learner can access a single complex schema from LTM to use in WM as one chunk. This then allows an experienced learner to work with up to 3 additional novel elements in WM. In contrast, novice learners in the same knowledge area lack highly developed schemas in LTM. These learners are only able to access loosely connected information elements from LTM that are represented as 2 or 3 separate chunks in WM; this leaves less room in WM for new information to be incorporated in revising a novice learner's understanding.

Instructional methods that are effective for maximizing learning in novices are usually not effective interventions for optimizing learning in more knowledgeable learners. The relative effectiveness of an instructional method is reversed when used with novice and experienced learners.^{21,22} An example of this *expertise reversal effect* occurs with the example-based learning strategy known as the *worked-problem effect*. Kalyuga et al.⁹³ demonstrated an expertise reversal effect comparing full worked examples with instructions guiding self-exploration in generating answers in 17 novice students learning electrical equations for relay circuits. Results demonstrated that fully written worked examples initially were superior to instructions guiding self-exploration in finding answers. However, after additional training, the advantage of fully worked examples reversed. For more knowledgeable learners, instructions guiding self-exploration became superior in generating improved performance on post-tests than fully worked out written problems.

From a CLT point of view, additional guidance associated with an achievement of a learning objective should reduce cognitive load in novice learners. This reduction in load might be critical for learning complex tasks that imposing a heavy load burden.⁹³

Van Gog et al.⁹⁰ argued that novice students may benefit from studying *process-oriented* worked examples that show solution steps and also expressly state the rationale behind those steps as opposed to *product-oriented* worked examples that illustrate only the solution steps to solve a problem. Studying process-oriented worked examples from a CLT perspective would stimulate learners' construction and automation of complex cognitive schema during training; this would allow for improved transfer performance over studying product-oriented worked examples.⁹⁰ Van Gog et al.⁹⁴ explored this argument and demonstrated an expertise reversal effect by comparing *product-oriented* worked examples and *process-oriented* worked examples. Eighty-one secondary students with basic physics knowledge but without application experience participated. Participants were randomly assigned to four groups, each receiving two training sessions with different worked problem strategies as follows; product-product, product-process, process-product, and process-process conditions. Participants completed a post-test between each training session. Results indicated no initial differences between the conditions after the initial training session. However, after the *second* training session, the process-product group was superior on post-test performance to the process-process group, illustrating an expertise reversal effect. With an increase of understanding from the initial study of process-worked examples, studying process-worked examples in the second training session became redundant for the learner. This resulted in an expertise reversal effect.

Leppink et al.⁹⁵ again demonstrated in 2012 the expertise reversal effect using worked problems as an intervention. In a study of 130 bachelor-level students in psychology and health sciences who were considered either low or high-level students in statistical reasoning ability, participants were randomly assigned to one of four conditions; reading only (control), answering open-ended questions, answering open-ended questions in which the answer had to include supporting arguments, and studying worked examples that included the type of arguments that students in the previous group were required to generate.⁹⁵ Results again confirmed the expertise reversal effect. Specifically, those students with low ability learned best from worked examples; conversely, the high-ability students learned more from answering open-ended questions with supporting arguments.⁹⁵

In summary, these three studies grounded in CLT demonstrate that, with more experience, the benefit of worked-examples for a learner disappears. Additional learning is then best facilitated through self-generated problem solving rather than through studying worked examples. According to the expertise reversal effect, instructional design or intervention must be crafted specifically to the experience or expertise level of the learner.^{22,96} In principle, novice learners cannot hold and mentally work with as much information in WM as more experienced learners.²² Instructional guidance or facilitation can substitute for underdeveloped schemas and does have the potential to facilitate schema construction in novice learners.²¹

The aim of this study was to focus on novice learners in the health professions in the area of interprofessional communication. Example-based learning by applying a facilitated tutored problem to the design of a simulation brief allowed us to explore the effects of

simulation design from a CLT cognitivist perspective. It was hypothesized that *novices who participate in a simulation experience with a tutored problem component* as opposed to a simulation experience without a tutored problem component, *would demonstrate superior performance in verbal communication skill and experience lower levels of extraneous cognitive load during the simulation activity.*

2.7 Measuring Cognitive Load with Subjective Scales

The ability to measure the type of cognitive load (intrinsic, extraneous, germane) is essential to CLT's capacity to guide instructional design to its fullest.⁹⁷ This is because CLT proposes that WM load is not simply the byproduct of the learning process but rather a critical factor that contributes to whether an instructional intervention is a success or failure.⁹⁷ In order to support this position, it is imperative that the construct of CL is measurable, which allows for the empirical establishment of the relationship between CL and performance or learning.^{97,98}

Paas et al.⁹⁹ initially conceptualized the measurement of CL in 1994 as having both task-centered and learner-center dimensions. The *task-centered dimension* is described as mental load, or processing demands imposed by a task and the environment. The task-centered dimension is determined by expert opinion, mathematical models, and task analysis. It is determined *a priori* as an estimate of anticipated total CL associated with a learning activity for a given learner.^{97,99} The *learner-centered dimension* is divided into mental effort, the WM resources needed to process task demands, and performance, a learner's overall achievement on the task.^{97,99}

Most subjective measures are multidimensional; an estimate of total CL comprises

mental demand, physical demand, temporal demand, performance, effort, and frustration.^{97,100} Additionally, subjective measures assume individuals are able to reflect on their cognitive processes and use rating scales to report on these processes after a learning activity. The most commonly used of these measures are the Paas Cognitive Load Scale⁹⁷ (Paas Scale) and the NASA-Task Load Index¹⁰¹ (TLX).

The Paas Scale is a single-item measure of total cognitive load first proposed in 1992.⁹⁹ Subjects are asked to rate the perceived intensity of their mental effort on a 9-point scale (1 = very, very low mental effort; 9 = very, very high mental effort). Reliability evidence to detect fluctuations in intrinsic load exists for the Paas Scale.^{97,102} The TLX has six subscales: mental demand; physical demand; temporal demand; performance; effort, and frustration. Individuals are asked to indicate the level of each dimension by making a mark on a visual analog scale (range: 0–20).¹⁰¹ Both of these scales, although widely used in the cognitive load literature, have the drawback of not being able to differentiate between or measure levels of the different types of cognitive load. Both have the goal of estimating total CL imposed on a learner over the entirety of a learning activity; however, without the ability to differentiate extraneous versus intrinsic load, it is impossible to ascertain if an educational intervention created greater or lesser extraneous load for a given learner. Naismith et al.¹⁰³ in an attempt to establish validation evidence for the commonly used CL measures for use with simulation experiences, found that the Paas Scale and TLX most likely capture only the construct of *intrinsic* cognitive load (ICL), although the level of ICL across scales varied within learners for a given activity.¹⁰³ This demonstrates that task complexity can be detected through subjective measures designed to capture intrinsic cognitive load.

Interventions responsible for lessening extraneous load are, according to CLT, interventions that optimize the potential for improved performance and learning.^{71,72} One aim of this study was to ascertain if a planned intervention, involving example-based learning that targets the brief component of a simulation experience, results in a lesser degree of extraneous load for a simulation activity. Moreover, if learners experience lesser extraneous load, do they perform better on a verbal communication skills outcome? Without the ability to differentiate and measure the different types of CL, this would be an impossible endeavor. Therefore, the Pass Scale and TLX are not appropriate tools for this study, as they cannot differentiate between ICL and ECL.

Two additional subjective rating scales of cognitive load, the Cognitive Load Component Questionnaire¹⁰³ (CLC) and Cognitive Load Inventory for Handoffs (CLI₄H),¹⁰⁴ are currently under development for use specifically with simulation learning activities. Both the CLC and CLI₄H are measures which attempt to differentiate total cognitive load into subtypes of cognitive load. Preliminary testing of the CLC indicates that it most likely only captures ICL; both instruments (CLI₄H and CLC) require further development in terms of evidence for construct validity.^{102,103}

A recent systematic review of CLT studies across simulation training contexts assessed the prevalence of validity evidence collected in an effort to support the use of various instruments measuring cognitive load during simulation training.¹⁰⁵ Of the 48 studies included in the review, all had included some degree of validity evidence for use of the chosen instrument. However, the authors noted that in most cases the evidence collected to support the use of a specific measure of cognitive load was limited. Most concerning to the authors was the lack of evidence for *response processes* in any study

across all measures.¹⁰⁵ Response process evidence is considered critical to understanding how individuals experience cognitive load, in this case in the context of simulation training. *None* of the scales used in the 48 reviewed studies were initially designed for use with simulation learning experiences, and therefore, *all* require determination of response process evidence prior to their continued use in this context. Outside of the simulation environment, an additional subjective scale has been developed by Leppink et al.^{24,106}; it is designed to capture the cognitive load sub-types a learner experiences in classroom activities. The scale and the literature discussing its derivation and validation to date will be discussed in the following section.

2.7.1 Cognitive Load Scale - (Leppink - Paas Scale)

Leppink et al.¹⁰⁶ recently developed a subjective measurement tool designed to capture the sub-types of cognitive load. The initial derivation of this tool was accomplished through a series of four studies involving undergraduate and graduate psychology and health sciences students participating in classroom learning activities.¹⁰⁶ The initial study in this series was an exploratory study that involved 56 PhD students in a statistics class. All participants completed the initial 10-item survey to provide data for an exploratory factor analysis of survey items. Results from the exploratory study indicated that the survey items loaded to three factors purported to represent intrinsic cognitive load, extraneous load and germane load. The second study was a confirmatory analysis involving 171 bachelor students in psychology classes. Results again provided support for the three factors as represented by specific questions on the survey. The third study, a cross-validation study, involved 136 bachelor students in statistics class. Results provided construct validation evidence for the tool in capturing ICL, ECL, and germane load

measurements across different classroom learning activities. The fourth study in this series was set as an experimental study involving 58 bachelor students in a statistics class. The analysis provided further validation for the initial 10-item tool in capturing three types of load during classroom learning activities. Additionally, the experimental study demonstrated the order in which the survey items are asked does not significantly influence internal consistency of the tool.¹⁰⁶ Lastly, Leppink noted that 'load' data are assumed to be interval in nature (when a Likert-type scale uses seven or more categories), and when a single construct is represented by more than one item on the scale. Both of these criteria for considering ordinal data as interval are met with the final version of the Leppink-Paas Scale.¹⁰⁶

Two additional studies reported in one paper provided further derivation of the scale and validation evidence for its use with students in both statistics and language classroom learning activities.²⁴ Analysis of these studies provided the final supporting evidence establishing the existing eight-item Leppink-Paas Scale (Appendix 2) that quantifies and differentiates between the constructs of intrinsic and extraneous cognitive load.²⁴ Questions 1-4 represent the construct of intrinsic cognitive load and questions 5-8 the construct of extraneous cognitive load for the current version of the tool.⁷¹ The internal consistency (Cronbach's alpha) for the intrinsic load items when administered as a post-test is reported as 0.872; for the four items intended to capture extraneous load, the internal consistency is 0.787.²⁴ These results indicate acceptable to good scale reliability.¹⁰⁷ Additionally, the validation study in this series used the same four groupings of example problem pairs discussed in the Van Gog et al.⁸⁹ study on worked examples in section 2.5.1.

Results replicated the findings of the Van Gog et al⁸⁹ study, providing further support for the worked problem effect.

The Leppink-Paas Scale can be evaluated according to the five accepted aspects of construct validity:¹⁰⁸

- *Consequential*: The potential risks of harm are low to students if the scores are truly invalid
- *Content*: The items appear to measure the intrinsic and extraneous load as they were developed by researchers with a noted expertise in Cognitive Load Theory. The theoretical foundation of the constructs of intrinsic and extraneous load appears sound as CLT has a 40-year history of development.
- *Response Process*: It is unclear how learners in the health professions interpret the meaning of the items on the measure in the context of SBL experiences, as the measure has only been applied in classroom learning activities.
- *Structural*: All items have undergone various forms of factor analysis testing in the development of the measure, and Cronbach's alpha for each construct has been identified,
- *Relationship/Generalizability*: The measure has been trialed with both graduate (PhD) and undergraduate (BS, BA) students in language, psychology, and statistics classroom settings (it was recently translated into French and applied to novice pharmacy students in a simulation learning environment).

The Leppink-Paas Scale was used in this study due to the robust series of high-quality studies during derivation and initial validation and its purported ability to differentiate between ICL and ECL. The current survey was recently applied in a study of

novice pharmacy students in a simulation learning activity. Tremblay et al.⁷³ used a French translation of the Leppink-Pass Scale in a within-subjects repeated-measures study and was able to demonstrate differences in both intrinsic and extraneous cognitive load between complex and simple scenarios. The confirmatory factor analysis (CFA) from Tremblay et al.⁷³ revealed that for the French translation of the survey, items 1-4 & 8 loaded onto the construct of ICL and items 5-7 to construct of ECL. Tremblay noted that the meaning of survey items may have been subtly altered due to their translation into French (leading to the difference in CFA results from Leppink et al.²⁴). Item 8 asks about mental effort in the context of clarity of instructions. If the focus of the translated version was interpreted more as mental effort as opposed to clear instructions, then it is reasonable the item correlated more strongly with other items that represent ICL as a mental effort.^{103,106} CFA was not possible for the current study, as the analysis would have required between 80 and 160 participants to perform. A globally accepted rule of thumb for the procedure is between 10-20 respondents per survey item.¹⁰⁹ However, to provide a measure of validity for the present study, the internal reliability for each part of the survey was calculated using Cronbach's alpha and found to be adequate (at .797 for items 1-4 representing ICL; and .701 for items 5-8 representing ECL). The tool in its English translation has yet to be applied in a between-subjects' study design with health professional graduate students in SBL experiences. Furthermore, there is a need to examine how learners in simulation experiences interpret the wording of the survey items. Understanding how graduate health professional students interpret the wording of this survey will provide a degree of response process validation evidence, an aspect of construct validity evidence as noted above. If scores are collected *without* controlling at the outset for possible errors from

word choice, those scores will lack the necessary degree of construct validity for interpretation. As Leppink states “validity of a measurement instrument is not established in one or two (sets of) studies; it is a journey in search for a chain of evidence, and to obtain that chain of evidence some elements in the instrument may need revision or adjustment.”²⁴

2.7.2 Response Process Validation

Response process validation evidence does not exist for scores generated via the Leppink-Paas Scale when used in simulation. According to modern validation theory, *response process* is one source of construct validation evidence. Response process validation has been identified in the medical education research community as necessary in the development of high-quality questionnaires and survey.^{108,110-114}

The American Educational Research Association (AERA), the American Psychological Association (APA) and the National Council on Measurement in Education (NCME) adopted modern validation theory as part of the *Standards for Educational and Psychological Testing*¹¹⁵ (*Standards*). The stated purpose of the *Standards* is “to provide criteria for development and evaluation of tests and testing practices as well as provide guidelines for assessing the validity of interpretation of test scores.”¹¹⁵ Modern validation theory replaces the prior distinctions of face, criterion, and content validity with the single unifying concept of construct validity.¹⁰⁸ The *Standards* support this concept by referring to construct validity as “the degree to which evidence and theory support the interpretations of test scores for proposed uses of tests”.¹¹⁵ Standard 1.12, Evidence Regarding Cognitive Processes states; “if the rationale for score interpretation for a given use depends on

premises about the psychological processes or cognitive operations of test takers, then theoretical or empirical evidence in support of those premises should be provided..."¹¹⁵

Recent medical educational literature suggests one means of obtaining response process validation evidence is through use of a qualitative methodology identified as the cognitive interview.^{110,112} In brief, a cognitive interview is an evidenced-based interviewing method meant to identify and analyze sources of response error in survey questionnaires.¹¹⁶ Specifically, the purpose of the method is to understand whether subjects understand the questions in the way intended by the researcher. It is to this purpose that cognitive interviews focus on the survey question and not on the person answering the questions in the interview.¹¹⁶ The method relies on conducting interviews with individuals who are representative of those who will be responding to the survey as intended for future data collection.¹¹² These individuals are presented with survey questions in much the same way as research participants will be administered the questionnaire in future studies. After completing the survey, the subjects are interviewed for 10 to 15 minutes using a series of pre-determined cognitive probes designed for a specific intent. Probes are generally open ended in nature and, for the purposes of this dissertation, focused on comprehension and interpretation of the wording used in the Leppink-Paas Scale. A recent review of cognitive interviewing in the medical education literature suggests that a sample size of 10 to 30 subjects is acceptable and that, for small-scale medical education projects, as few as 5 or 6 subjects may provide enough useful information.¹¹⁰ Specific guidance for conducting a cognitive interview and analysis of results is detailed in multiple published sources.^{110,112,117} These sources guided the methodology of this study.

2.8 Overall Contributions

The main contributions of this study are to the *scholarship of teaching and learning* (SoTL) in the use of simulation in entry-level health professional education. The use of simulation in this venue has been studied mainly through general educational research projects and not with a specific focus on the SoTL. The issue with prior research is that while all SoTL is educational research, not all educational research qualifies as SoTL. Potter and Kustra¹¹⁸ have proposed a definition for the concept of the SoTL, initially proposed by Boyer,¹¹⁹ and refined by Hutchings and Shulman¹²⁰ as:

“the systematic study of teaching and learning, using established or validated criteria of scholarship, to understand how teaching (beliefs, behaviours, attitudes, and values) can maximize learning, and/or develop a more accurate understanding of learning, resulting in products that are publicly shared for critique and use by an appropriate community.”¹¹⁸

As many have observed, there exists a plethora of evidence that SBL in health professions education works, but what is lacking is the understanding of *how and why it works*. In attempting to address how and why SBL works by viewing this dissertation through the lens of Cognitive Load Theory, the goal is to contribute to health professional educational reform in fostering true collaborative practice for the 21st century. Specifically, this study adds to the understanding of measuring the different components of cognitive load that learners' in the health professions experience during simulation based learning. Additionally, by applying teaching principles from CLT (tutored problem solving to elicit a worked problem effect) to the SBL environment, health professions educators gain the

needed evidence to establish and refine best practices for effective teaching with simulation.

Chapter 3 Methodology

3.0 Introduction

This study involved three components, one qualitative and two quantitative in their design. The qualitative component aimed to establish response process validation evidence for scores generated from the Lippink-Paas Scale. A cognitive interview was used as the methodology for the qualitative component. The initial quantitative component involved establishing inter and intra-rater reliability evidence for scores collected on an I-SBAR verbal communication tool. The variables captured by these instruments were the primary outcomes for a subsequent randomized control trial designed to provide insight into the following questions: 1) Does participation in a simulation brief structured as a tutored problem versus a traditional simulation brief affect the relative amounts of cognitive load types experienced by a health professional student during an active simulation? and 2) Does participation in a simulation brief structured as a tutored problem versus a traditional simulation brief result in better performance on a verbal communication task by health professional students? Ethics approval for the study was obtained through the Institutional Review Boards at Samuel Merritt University in Oakland California (Primary) and Nova Southeastern University in Fort Lauderdale Florida (Secondary).

The chapter is organized according to the three components introduced above. For each; necessary background is summarized, specific research methods, qualitative and quantitative analysis discussed and specific resource requirements included.

3.1 Component 1: Establishing Validation Evidence with Cognitive Interviews for the Leppink-Paas Scale Used in Simulation-Based Learning with Health Professional Students

3.1.1 Background

One of the primary challenges in applying cognitive load theory (CLT) principles to the design of simulation-based health professional education is the limited evidence supporting the use of existing measures of cognitive load (CL) within simulation-based learning (SBL).^{103,121,122} In particular, there is a lack of investigation into whether a recently developed measure of CL, The Leppink-Paas Scale²⁴ is sufficiently sensitive in capturing the differences in the type of CL (intrinsic vs. extraneous) experienced by learners in SBL (that would otherwise be predicted based on CLT alone). Ascertaining how students in the health professions interpreted the wording of the existing measure immediately after participating in a simulation activity provided an initial step in addressing this gap.

3.1.2 Methods

3.1.2a Participants:

Health professional graduate students engaged in SBL experiences from the Doctor or Master of Occupational Therapy (OT), Doctor of Physical Therapy (PT), Doctor of Podiatric Medicine (PM), Advanced Bachelor of Science in Nursing (ABSN), and Master of Physician Assistant (PA) programs from Samuel Merritt University (SMU) were the population invited to participate in cognitive interviews conducted by the Director of the Health Science Simulation Center (HSSC) at SMU, an experienced qualitative researcher. Participation was not limited to any specific level/year of student from these programs.

Purposive non-proportional quota sampling allowed for representation from all subgroups in the population.

The literature supports cognitive interviewing methodology as a component of initial survey/instrument design, as well as prior to the use of an existing survey or instrument in a newly defined population.¹¹⁰ The cognitive interviewing literature suggests a sample size of between 5-30 participants as sufficient, depending upon the scope and developmental stage of the survey or instrument being studied.^{110,112} Considering the availability of students able to participate during the academic term as well as a desire to have all programs represented, a total of 11 participants were interviewed. Included in the sample were two students each from PA, OT, PM, and ABSN, and three students from PT. All participants were at least 21-years of age, enrolled at least part time at Samuel Merritt University in one of the aforementioned programs, and had experienced simulation-based learning as part of their educational programs.

3.1.2b Qualitative Interview Procedures:

The principle investigator (PI) met with the HSSC Director prior to the Fall 2019 academic term to plan when cognitive interviews would take place. Previously scheduled formative SBL experiences from each of the targeted programs were identified as appropriate for soliciting participants. The PI, a Doctor of Physical Therapy program faculty member, solicited participants from all programs. To ensure there was no ethical conflict, PT students in their third year of study and no longer being taught by the PI were solicited to fulfill the quota for PT participation. A verbal solicitation (Appendix 3) explained the purpose of the research and specifics of what was involved during the cognitive interview process. A written version of the solicitation was made available to

potential participants. Participants were screened according to a brief questionnaire (Appendix 4). Prior to the start of the SBL experience, participants were given an opportunity to read and clarify questions; they also signed an informed-consent document (Appendix 5). The informed consent included obtaining permission to audio-record the full cognitive interview. Immediately after the SBL activity and prior to any scheduled debrief, participants were escorted to a designated interview room and asked to complete the Leppink-Paas Scale. The survey required no more than five minutes to complete and asked responders to assign a numeric value of between 0-10 to each of eight statements, 0 representing “not at all the case” and 10 representing “completely the case”.

Immediately following completion of the Leppink-Paas Scale²⁴, participants began a one-on-one, face-to-face cognitive interview with the Director of the HSSC at SMU. Structured verbal probes were asked of each participant in order to capture interpretation of and meaning brought to the words and phrases that make up the Leppink-Paas Scale. Participants had access to their completed survey for the duration of the cognitive interview. The interview was constructed as a retrospective verbal-probing cognitive interview led by an experienced qualitative researcher not involved with grading/scoring the participants as faculty at SMU. A verbal probing interview was chosen as opposed to a think aloud interview it is thought easier for participants to answer structured questions, the time burden for participants is typically less and the analysis tends to be simpler.¹²³ Detailed instructions were provided to the cognitive interviewer and available during the interviews (Appendix 6). Each cognitive interview lasted between 5 and 7 minutes and adhered to the following standard format:

1. The interviewer read the introduction to the cognitive interview process (Appendix 7) and asked the participant for any clarification or questions.
2. The interviewer asked each participant nine predetermined verbal probes (Appendix 8). one at a time in a specified order After the participant answered each probe, the interviewer asked follow-up questions for clarification as necessary.
3. The process concluded when all nine verbal probes were asked and sufficiently answered as determined by the interviewer.

Total time burden for each participant was 20-25 minutes. Participants received a \$5.00 coffee bar gift card as compensation for their time. Interviews were digitally audio-recorded and transcribed by a student research assistant onto a data collection sheet (Appendix 8) for analysis.

3.1.2c Data Analysis:

Transcribed interviews were stored in hard copy as well as digital copy formats. All interviews were identified according to professional program and 01, 02 or 03 according to participant being interviewed to maintain participant anonymity. Participants were not identified by name at any time during the interview. For example, the initial interview of a student from the PT program was given the identifier DPT 01. All transcribed records and digital audio recordings were transferred to a flash drive and stored in a locked file cabinet in the university office of the PI. The PI has sole access to the data and allowed access to designated research assistants as needed for transcription and analysis purposes. All transcribed interviews and interviewer comments were compiled according to each specific verbal probe on the cognitive interview data collection sheet (Appendix 8). *Project Text Summary* analysis for each verbal probe was generated (Appendix 9).^{117,123} According

to Willis, this type of analysis involves uncoded raw data in the form of “quotes and notes” to provide a description of dominant themes, conclusions, and problems as related to the survey.¹²³ Project text summary is an aggregation accomplished across all interviews within a given project. A similar term to project text summary in qualitative literature is narrative summary.¹²³ Willis describes the difference as “narrative” referring to the verbatim story given by each participant while “text summary” is inclusive of narrative with the addition of associated facts and other forms of semantic memory.¹²³ Project text summary analysis is the dominant analysis approach in summarizing cognitive interview data.^{112,123}

3.2 Component 2: Inter- and Intra-rater Reliability Evidence for Scores Generated from a Tool Capturing Verbal Communication Skills Using the I-SBAR Format.

3.2.1 Background

Psychometric evidence regarding inter-rater and intra-rater reliability evidence for performance scores was established using qualitative methods; evidence was collected on a tool designed to capture verbal communication skills using the I-SBAR format. The I-SBAR Verbal Communication Measure (Appendix 10) was developed by faculty at SMU for use in a simulation environment. Judgments made on the basis of the scores generated from the tool can be interpreted based on the evidence establishing a degree of construct validity. 1) The tool has undergone several revisions in wording and structure after input from three nursing and two physical therapist educators. 2) The tool has been used in two formative manikin-based simulation experiences with second year DPT students. One objective of this experience required learners to verbally report an I-SBAR formatted summary to a

health care team member. 3) In discussions regarding content captured from the tool, nursing and PT faculty receiving and scoring the verbal communication agreed that the I-SBAR Communication Measure captured the important aspects of a verbal I-SBAR summary for the given SBL experience.

Establishing inter and intra rater reliability evidence required the assistance of four faculty raters from four different graduate health professional programs at SMU. Each rater scored seven I-SBAR verbal communication audio recordings at two different time points. Establishing the inter-rater and intra-rater reliability evidence for each rater allowed for the determination of a most reliable rater. The most reliable rater was then chosen to score all audio recordings collected during the second quantitative component of this work in an effort to limit the degree of random error associated with scores generated from the tool.

3.2.2 Methods

3.2.2a Participants:

Four participants for this inter intra-rater reliability study were purposely recruited from the SMU faculty. The PI solicited participation from individuals known to meet all of the following inclusion criteria: 1) individuals licensed as healthcare providers in the professions of nursing, occupational therapy, or physical therapy, 2) individuals having at least 2 years of full-time work experience on health care teams prior to transitioning to academic/clinical teaching, 3) individuals having experience with Team STEPPS¹²⁴ communication tools, either through participating in a Master Training course to become Team STEPPS trainers for faculty, students and staff at Samuel Merritt University (SMU) or as faculty in the HSSC who are trained in Team STEPPS at a Foundations level minimum (Appendix 11).

Recruited faculty were also responsible for modeling Team STEPPS communication tools, including I-SBAR with the students at SMU. Each recruited participant had the potential to assist with scoring I-SBAR communications recordings in a subsequent study depending upon their reliability scores.

3.2.2b Procedures:

This component of the study involved blinded data de-identified audio recordings of students who have since graduated from SMU, allowing for the Exempt Review Process at SMU and the Waiver of Informed Consent Process for NOVA Southeastern University. The PI selected seven I-SBAR communication recordings from 34 existing recordings created during a formative cardiopulmonary simulation encounter for 2nd year Doctor of Physical Therapy students in the Summer of 2017. Each recording lasted 2-3 minutes. Three of the recordings represented above-average performance, two were average performance, and two below-average performance. The selected recordings were reviewed by a second DPT faculty who provided similar ratings of performance.

Each rater was provided a copy of the I-SBAR Verbal Communication Measure and a standard set of instructions when meeting individually with the PI. During the meeting, each rater read the materials and had questions resolved. The PI and rater together listened to one sample audio recording and resolved questions. Each rater was provided with 14 I-SBAR Communication Measures, seven labeled “O” for original order and seven “A” for alternate order. Raters were sent an electronic link to a series of seven audio files housed in two separate file folders, “original order” and “alternate order”. The PI pre-determined the order of the recordings for each folder.

Raters were asked to listen and score the recordings in the order they appeared in the “original order” file within 48 hours of meeting with the PI. They were instructed to listen to each recording only once and to listen to all recordings in the folder in one sitting. They were free to score each recording during listening or immediately after listening; however, they had to finish scoring a recording before moving on. A minimum 48-hours (but no more than 72 hours) after scoring the recordings in the “original order” folder, raters repeated the process with the recordings in the “alternate order” folder. Raters scored all recordings in a private quiet space of their choice. The PI was not present during scoring. Once all meetings with raters were completed, the PI listened and scored all recordings according to the established protocol. Total time burden for each rater was between 90 and 120 minutes inclusive of the initial meeting with the PI.

3.2.2c Data Analysis:

i. Intra-rater Reliability

To establish the intra-rater reliability of the tool, Pearson product moment correlations were calculated between trial 1 and 2 for each rater. Since correlation does not address agreement, additional agreement statistics were calculated. For this part of the analysis, agreement was defined as the percentage of agreement or the number of times the rater matched his or her rating between trial one and trial two.

ii. Inter-rater Reliability

To establish the inter-rater reliability for the I-SBAR tool, Pearson product moment correlations were calculated between each pair of raters as well as percentage of agreement between raters. In addition, intra-class correlation (ICC) coefficients were calculated to assess the degree of association across all raters. For the ICC analysis, model 2

and form 1 was used. Model 2 was selected because these four raters are considered representative of other similar raters. Form 1 was selected because each rater (within each trial) only provided one rating. Interpretation of the analysis was based on guidelines according to Koo and Li.¹²⁵ Additionally, the data were presented graphically in order to visualize unreliable raters.

iii. *Reliability with Established Rater*

From the above analysis a “most reliable” rater was established, and their scores were compared to those of an expert rater, in this case the PI. Pearson product moment correlations were calculated as well as percentage of agreement. To determine if any pattern existed between the expert rater and the most reliable rater, Bland-Altman Plots were constructed for the two trials.

3.3 Component 3: Application of Example-Based Learning Principles to Simulation Design to Improve Verbal Communication Skills in Novice Health Professional Graduate Students. A Randomized Post-Test Blinded Control Group Study

3.3.1 Background

Understanding if CLT principles applied to SBL lead to similar outcomes on performance as when these principles are applied to classroom learning was the goal of this component of the overall study. The example-based learning principle includes learning by studying worked out problems or through step-by-step guidance by tutors and has a robust evidence base indicating the strategy is effective in facilitating understanding for novice learners.^{19,87} Compared to conventional problem solving strategies, example-based learning strategies appear to reduce extraneous load allowing a learner to devote

available WM capacity to studying a worked-out solution or a facilitated solution thereby constructing mental networks (schema) in LTM for solving similar problems in the future.^{19,87} The advantages of example-based learning over conventional problem solving is known as the ‘worked example effect’.

What is not known is whether example-based learning strategies translate to improved learning/performance from simulation experiences. Specifically explored in this component of the study was if the *brief* component of a simulation experience can act as the container for a facilitated tutored-problem in generating a worked problem effect in novice health professional student.

3.3.2 Methods

3.3.2a Participants

i. Characteristics:

The population of study were graduate students pursuing an entry-level clinical degree in the health professions. Students from the Doctor or Master of Occupational Therapy (OTD) (MOT), Doctor of Physical Therapy (DPT), Doctor of Podiatric Medicine (DPM), Entry Level Master of Science in Nursing (ELMSN), Advanced Bachelor of Science in Nursing (ABSN) and Master of Physician Assistant (PA) programs at Samuel Merritt University (SMU) were invited to participate in this study. All of the included programs represent entry-level clinical degree programs at SMU, open to students who have earned at least a bachelor’s degree. Additionally, participating students were considered *novice*, having completed basic science course work but having limited exposure to an inpatient inter-professional healthcare setting.

Specific inclusion criteria included being age 21 or older, completing Team STEPP's training through SMU and the basic physiology and anatomy course work for their programs, having no more than 2 weeks of sequential full-time clinical exposure in their role as a student while at SMU, and being a currently enrolled student at SMU at the time of data collection.

Additionally, students enrolled in targeted programs returning to school to pursue a second career from a prior career in health care were excluded from participating. For example, a student enrolled in the Physician Assistant program who had a prior career in healthcare as an RN, LVN, nursing assistant, or Medical Social Worker etc. would have been excluded based on prior work history. Lastly, any student who participated as a subject for the cognitive interview study associated with this work, was excluded from participation.

ii. *Sample Size:*

Sample size was determined *a priori* based on common conventions of setting the Type I and Type II error rates at $\alpha=0.05$ and $\beta = 0.20$ respectively, and power by default at 0.08. Effect size estimates for the sample size projection were based on results from Leppink et al.²⁴ In this study, the authors demonstrated that participants who initially studied worked examples, compared to participants who initially solved problems autonomously, performed much better on a post-test. The study involved four treatment groups comprising 18 to 20 subjects in each group. The size of this effect was calculated using the eta-squared (η^2) statistic appropriate for the complexity of study design (MANOVA) and represents a medium to somewhat large effect size at $\eta^2=0.094$.²⁴ The estimated effect size used for sample size calculations in this study of a less complex design than the study by Leppink et al.¹⁰⁶ was based on a Cohen's *d* of 0.75, representing a

moderate to large effect. Using an online calculator, the sample size estimated for the proposed study was 29 per group for a total of 58 participants.¹²⁶

iii. *Sampling method:*

Non-probability convenience sampling was conducted between August 2018 and October 2018. The sample is considered a non-probability sample including entry-level health professional students from a single university campus in California. Snowball sampling also occurred as recruited students informed and encouraged others in their cohorts to participate.

iv. *Recruitment:*

Recruitment took place on the SMU campus in Oakland California. Recruitment methods included the posting of a flyer (Appendix 12) on campus in multiple locations and sent as a bulletin through the campus wide e-mail system. The flyer included an explanation of the project, a request for participants, and the PI's contact information. Additionally, the PI recruited "faculty champions" associated with each program. These champions distributed flyers to their students as well as allowed the PI to make several guest appearances in their classes specifically to recruit participants. Guest appearances in classes proved the most effective and efficient means of recruitment. During class recruitment, the faculty of record stepped out so as not to influence student participation decisions.

v. *Screening:*

Screening was completed at the time of recruitment and involved the subject answering a series of questions confirming inclusion and exclusion criteria (Appendix 13). If subjects met the criteria for inclusion, they self-selected a specific participation date and

time that matched when they were present on campus and not in classes. These dates and times were scheduled by the PI with the HSSC with an awareness of when certain groups of students were likely to be free. Once scheduled, subjects were considered a participant of the study.

3.3.2b Procedures:

i. Instruments:

The I-SBAR Verbal Communication Measure (Appendix 10) provided two dependent variables, a total performance score of 0-10 points and a separate assessment performance score of 0-5 points. Judgments made on the basis of these scores were interpreted based on the following validity evidence. The tool was used in two simulation-based learning activities that required learners to verbally report an I-SBAR handoff to another healthcare provider, after which revisions to the wording and structure were made from input by both nursing and physical therapist educators at SMU. Educators scoring the I-SBAR verbal communication for these learning activities agreed that the tool captured the important expected aspects of a verbal communication. Inter- and intra- rater reliability evidence for a group of four raters determined a “most reliable” rater in scoring the tool from a prior study. This rater was not part of the simulation experiences associated with this phase of the research and therefore was blinded to subject group assignment when scoring.

The Leppink-Paas Scale (Appendix 2) provided two additional dependent variables: intrinsic cognitive load and extraneous cognitive load. The instrument is open access and does not require permissions for use. The survey consists of 8 statements and asks responders to assign a numeric value of between 0-10 to each of the 8 statements, with 0 representing “not at all the case” and 10 representing “completely the case”. In the most

current version of the survey, statements 1-4 represent the construct of intrinsic cognitive load (ICL), while statements 5-8 represent the construct of extraneous cognitive load (ECL). Scores for level of ICL and ECL were calculated by summing responses for each of the 4 statements representing ICL and ECL. The PI or research assistant input raw summed and individual item scores into an Excel data file for transfer into an SPSS data file.

ii. *Treatment:*

The experimental study was designed as a two arm (experimental vs. control) post-test only study. In an effort to avoid adversely affecting the internal validity of the study by sensitizing participants to the outcomes potentially influencing their score on post-test measures, no pre-test measure of I-SBAR verbal performance was administered. Blocked randomization is recommended to ensure equal sample sizes for data collected over a several month time period.¹²⁷ Blocks of 4 with two treatment arms resulted in the randomization plan generated from www.randomization.com created on 8/14/18 (Appendix 14). Participants were randomly assigned to either the experimental or control arm of the study based on the randomization plan. Each was blinded to their group assignment, ensuring a degree of internal validity.

Each participant progressed through the study according to a standardized flow sheet (Appendix 15) with the PI acting as the facilitator. Participants assigned to the control arm experienced a traditional simulation brief that included receiving a paper with relevant patient and case details (Appendix 16), a verbal explanation of the goals and objectives for the simulation activity, a verbal general overview of the encounter, and up to 5 minutes physically spent in the actual simulation environment set for the activity. The traditional brief ended with a learner-initiated question and answer period. Control

participants were then allowed up to an additional 10 minutes of unstructured time alone in a quiet room to prepare however they wished for the simulation activity. Those assigned to the experimental arm participated in the identical brief as described for the control participants with the exception that the terminal 10 minutes of self-preparation was structured as a *facilitated example-based learning session* for the simulation activity. This 10-minute component was designed as a tutored problem/reflection-before-action component according to CLT principles. The facilitator asked the learners a series of questions designed to bring their knowledge in pieces together prior to the simulation activity. The questions for this component of the brief were; “Let’s review what you know about I-SBAR communication from your Team STEPPs training. What do each of the component parts of I-SBAR stand for? Where and how might you gather the information that will allow you to verbally report a complete I-SBAR in the simulation environment you are about to enter? What difficulties do you anticipate you will encounter once you enter the environment and how might you plan to overcome them?” Once these questions were discussed and follow-ups answered, the participants in the treatment arm spent any remaining time of the 10-minute block in self-preparation. Most participants in the treatment arm had between 1.5 and 3 minutes of self-preparation time.

iii. *Description of the Simulation Activity:*

The simulation activity was designed at a level appropriate for novice health professional students and took into account levels of complexity, student support, and fidelity from a Cognitive Load Theory perspective.⁷⁰ The simulation activity involved participants interacting through a manikin-based simulation with a patient who had an undiagnosed cardiac arrhythmia labeled as possible atrial fibrillation. The simulation

environment included a standard patient monitor with associated alarms and auditory cues running live during the simulation. Monitor alarms and auditory cues were intentionally not silenced as a support strategy for novice health professional students. The intention was to avoid what Simons refers to as *inattentional blindness*: when input to sensory memory does not rise to conscious awareness and therefore is not taken into working memory for processing.⁷⁸ For novice health professional students, providing external sensory cues can be a form of student support. The variables displayed on the monitor were HR, BP, O2 saturation, RR, and Cardiac lead II rhythm strip. During the simulation activity, the monitor displayed 2-3 episodes of rapid atrial fibrillation for 30-40 seconds each. During these episodes, participants were exposed to monitor audio cues indicating an increase in HR from the high 70s to the low 140s. No other monitor variables changed during these episodes. Additionally, the patient verbally indicated an awareness of each episode. Participants had five minutes in the simulation activity to identify and gather all information required to report a complete verbal I-SBAR communication to another health provider. Following the five-minute simulation activity, the PI playing the role of another member of the patient's care team, entered the room and asked the participant for an assessment or report. The PI began the encounter with the following statement; "Hi I'm (states name and title), can you give me an update for (pt. name)?" Once the PI entered the room, the monitors to the patient were frozen and the student provided their verbal I-SBAR which was then recorded. Once the participant finished giving a verbal report, they were escorted back to the briefing room and asked to fill out the Leppink-Paas Scale. See Appendix 17 for details regarding the simulation case and simulation plan.

iv. *General Flow of Participants:*

After recruitment and scheduling, participants were sent e-mail reminders regarding the place and time of their simulation. A research assistant or the PI welcomed each participant and escorted them to the assigned briefing room. They were asked to read and sign informed consent documents and given an opportunity to ask questions (Appendix 18). The PI then provided an orientation to the general flow of the study. The assigned brief (tutored problem/reflection-before-action vs. traditional) followed and lasted approximately 15 minutes. The participant was then escorted by the PI or research assistant to the simulation activity, asked to enter when a cue was provided, and interact in the simulation environment for five minutes. At the end of five minutes, the PI entered the simulation environment playing the role of a member of the health care team and asked the participant for a patient update. The participant's response was audio recorded and, when finished, the participant was escorted back to the briefing room and asked to complete the Leppink-Paas Scale.

Once the Leppink-Paas Scale was completed and collected, participants were informed that data collection had ended and were offered a \$10.00 coffee store gift card. All were reminded not to discuss their experiences with other students for the duration of the study. Participants were also offered an opportunity to participate in a closing debrief with the PI for 5-7 minutes. Participation in the closing brief was optional and not required for study data collection; however, it is a standard of practice in all simulation experiences. All study participants also participated in a facilitated debrief with the PI.

3.3.2c Data Analysis:

Prior to any planned comparisons using data from the Leppink-Paas Scale the internal reliability of each part of the tool (intrinsic and extraneous load) and the tool overall was

calculated using a Cronbach's alpha. Scores from the four dependent measures for the planned comparisons were treated as ordinal level data. The dependent variables of *intrinsic cognitive load* (ICL) and *extraneous cognitive load* (ECL) were calculated from scores associated with statements on the Leppink-Paas Scale. Statements 1-4 represent the construct of ICL, and statements 5-8 represent ECL. The range of scores for each statement was 0-10. For each participant, scores for statements 1-4 and 5-8 were summed, and means and standard deviations for each group (control vs. treatment) were calculated. To address the research question, "Is there a difference between groups for the intrinsic load sum and the extraneous load sum?", independent t-tests were planned with the alpha level set at $p \leq 0.025$. The dependent variables of *total I-SBAR* performance and *assessment I-SBAR* performance were scored on an ordinal scale from 0-10 and 0-5 respectively. For each participant, scores were summed, and means and standard deviations for each group (control vs. treatment) were calculated. To address the research question, "Is there a difference in total I-SBAR performance or assessment I-SBAR performance scores between treatment and control groups?", independent t-tests were planned with alpha level set at $p \leq 0.025$. In the event that homogeneity of variance tests showed significance or post hoc power calculations proved low, planned comparisons were then analyzed using the non-parametric Mann-Whitney U test. Effect size determination using Cohens *d* was also completed for each comparison.

Lastly, to address the research questions, "Is there a significant inverse relationship between extraneous load and *total or assessment I-SBAR* score for both groups?", and "Is there a significant inverse relationship between intrinsic load and *total or assessment I-*

SBAR score for both groups?”, associative analysis using both Pearson Product Moment and Spearman correlations were performed with alpha set at $p \leq 0.025$.

3.4 Summary

This study involved the qualitative method of cognitive interviewing to explore how wording on a survey differentiates between two types of learner-experienced cognitive load and therefore influences the interpretation of scores generated by the tool. Additionally, quantitative methods were used in establishing inter and intra-rater reliability evidence for scores collected on a newly created verbal communication tool. Finally, quantitative methods generating data analyzed with null hypothesis significance testing and effect size calculations were used in a randomized experiment to provide insight into the following questions: 1) Does participation in a simulation brief structured as a tutored problem versus a traditional simulation brief affect the relative amounts of cognitive load types experienced by a health professional student during an active simulation? and 2) Does participation in a simulation brief structured as a tutored problem versus a traditional simulation brief result in better performance on a verbal communication task completed by health professional students?

Chapter 4 Results

4.0 Introduction

The overall focus of this dissertation was to analyze if example-based learning principles from Cognitive Load Theory applied to the design of a simulation-based learning experience had any effect on verbal communication performance outcomes in health professional students. Three studies made up separate but related components of this work to provide insight into four main research questions. In this chapter, the results from each of the three related studies are presented subsequent to how they pertain/relate to each of the four main research questions.

4.1 Research Question 1

The primary aim of this dissertation was to answer the question; “How does performance, measured by an I-SBAR verbal communication tool, compare between novice health care professional students who participate in a brief designed as a tutored problem vs. a traditional brief for a given simulation-based learning experience?” The alternative hypothesis tested was: Novice health care professional students who participate in a brief designed with a tutored problem will score higher on an I-SBAR verbal communication skill compared to peers who participate in a traditional brief for a given simulation-based learning experience.

4.1.1 Psychometric Properties of the I-SBAR Communication Measure

Establishing reliability and validity psychometric properties of a tool, the I-SBAR Communication Measure (I-SBAR CM) (Appendix 10) created by the PI was necessary prior to testing the alternative hypothesis. This tool was one of two primary outcome measures

for the companion randomized trial of this study. The I-SBAR CM is scored on a scale from 0-10 and is intended to measure performance on verbal communication skills between healthcare providers. To establish the psychometrics for this tool, seven participants were rated by four raters. Each rater was asked to score the participants over two trials. In addition, the tool developer (the PI) was used as an “expert rater” to validate the scores provided by the most reliable rater of the four. The results from the psychometric analyses were used to select the most reliable and valid rater as the blinded rater who then scored all recordings generated in a subsequent experimental study.

The descriptive data for each rater by trial can be found in Table 4.1. The mean scores for raters 1 and 4 on visual inspection appear closest to those of the expert rater.

Table 4.1 Descriptive I-SBAR scores by rater

Rater	Trial	Mean	Standard Deviation	Min score	Max score
1	1	6.57	1.51	5	9
	2	6.14	1.68	5	9
	Average	6.36	1.57	5	9
2	1	8.29	2.06	5	10
	2	8.43	1.72	5	10
	Average	8.36	1.80	5	10
3	1	7.14	1.07	6	9
	2	7.00	1.83	4	9
	Average	7.07	1.27	5.5	9
4	1	6.14	1.07	5	8
	2	6.29	1.11	5	8
	Average	6.21	1.04	5	8
Expert	1	6.14	1.77	4	9
	2	6.43	1.62	5	9
	Average	6.29	1.65	4.5	9

To establish the intra-rater reliability of the tool, Pearson product moment correlations were calculated between trial 1 and 2 for each rater. Since correlation does not address agreement, additional agreement statistics were calculated. For this part of the analysis, agreement was defined as the percentage of agreement or the number of times the rater matched his or her rating between trial one and trial two. The intra-rater reliability between individual raters' scores over trial one and two can be found in Table 4.2. In addition, paired t-tests were run between trial 1 and 2 for each rater, there were no significant differences found at $p \geq .078$. Rater 1 had the strongest correlation at $r=.95$ while

Table 4.2 Intra-Rater Reliability Statistics

Rater	Pearson Correlation between trial 1 and 2	Significance value (p value) for Pearson correlation	Percentage of paired ratings (out of 7) in agreement
1	.949	.001 *	57%
2	.808	.028 *	57%
3	.512	.240	43%
4	.801	.031 *	57%

* significant
alpha level set at .05

rater 3 had the weakest correlation at $r=.51$. Three of the four raters had significant associations between trial 1 and trial 2. According to Portney and Watkins, a correlation value ≥ 0.75 is considered "good to excellent."¹²⁸ When comparing agreement statistics, three of the four raters agreed between trial 1 and trial 2 for 4 out of the 7 rated participants.

Next, the inter-rater reliability for the I-SBAR CM was assessed. Pearson product moment correlations were calculated between each pair of raters. The results from these

correlational analyses can be found in Table 4.3. Only one pair of raters (rater 1 and 3) had a significant association between ratings for trial 1. During trial 2, raters 1 and 4 were the only pairing with a significant association.

Table 4.3 Inter-Rater Reliability Statistics

Rater	Rater	Pearson Correlation (Trial 1)	Significance value (p value) for Pearson correlation	Pearson Correlation (Trial 2)	Significance value (p value) for Pearson correlation
1	2	.367	.418	.496	.258
	3	.766	.045 *	.599	.155
	4	.457	.303	.779	.039 *
2	3	.433	.332	.691	.086
	4	.206	.658	.187	.668
3	4	.563	.189	.164	.725

* significant
alpha level set at .05

The scores for each rater (by participant) for trial 1 and trial 2 demonstrate that rater 2 scored participants higher than the other raters for five of the seven ratings. In trial 1, raters 1 and 3 had the highest agreement for five of the seven rated participants or 71% of the time. However, in trial 2, raters 1 and 3 only agreed 43% of the time (3 out of 7). As an extension of the inter-rater reliability results above, intra-class correlation coefficients (ICC) were calculated to assess the degree of association across all raters. For the ICC analysis, model 2 and form 1 was used. Model 2 was selected since these four raters are considered representative of other similar raters. Form 1 was selected since each rater (within each trial) only provided one rating. For trial 1, the ICC(2,1) was .391 (95% CI: .026-.814), $p=.017$ and for trial 2, the ICC(2,1) was .488 (95%CI: .110-.858), $p=.004$. There were significant associations for both trials when all raters were included, however these ICC values should be considered a “poor association” according to Koo and Li.¹²⁵ At this

point in the analysis, the outcomes indicated that rater 1 was the most reliable of the four raters, however the scores required validation.

To determine if rater 1 was providing valid scores, these scores were compared to the tool developers' (expert rater) scores for the seven participants over two trials. The intra-rater reliability for the expert rater was $r=.905$, $p=.005$. The inter-rater reliability between the expert rater and rater 1 was $r=.959$ ($p=.001$) for trial 1 and $r=.957$ ($p=.001$) for trial 2. There were no differences in the means between the two raters at trial 1 ($p=.635$) and at trial 2 ($p=.751$). These two raters agreed four out of seven times or 57% in trial 1 and five out of seven trials or 71% for trial 2. The ICC(2,1) was .933 (95% CI: .805-.987), $p=.000$ suggesting a "excellent association" for rater 1 and the expert raters' scores on trials 1 and 2 combined.

In summary, results from the above analysis found significant intra-rater reliability in 3 of the 4 raters with 57% agreement but overall poor inter-rater reliability between the two trials using the I-SBAR CM. Scores from rater 1 however demonstrated the strongest psychometric properties of the four raters in the analysis and therefore these scores were compared to those of the expert rater. The analysis demonstrated strong inter-rater reliability and adequate agreement between rater 1 and the expert rater. Based on these results rater 1 was chosen as the blinded rater to score all I-SBAR CM recordings generated in the subsequent experimental study.

4.1.2 Between groups comparisons for I-SBAR performance

To answer the questions "Is there a difference in *total* I-SBAR scores between the treatment and control groups?", and "Is there a difference in *assessment* I-SBAR scores

between the treatment and control groups?” a two-arm randomized controlled trial was performed. I-SBAR CM performance data were not collected from four participants due to technological failure of recording equipment. The data for these four participants were removed from subsequent analyses leaving 54 participants; 28 participants in the control group and 26 in the treatment group. The I-SBAR CM consists of 14 items that were summed for a total of 10 points, with a sub-domain for “assessment”, for a total of 5 points. The descriptive summary from the I-SBAR communication measure can be found in Table 4.4. The table includes means, standard deviations as well as minimum and maximum scores for each of the dependent variables (total score and assessment score) by group.

Table 4.4 I-SBAR summary statistics for each dependent variable

Dependent Variable	Group	Mean	Standard Deviation	Minimum	Maximum
I-SBAR CM Total Score (0-10)	Control	4.61	1.46	1.5	8
	Treatment	6.06	1.80	1.5	9.5
I-SBAR CM Assessment Score (0-5)	Control	1.05	.832	0	3
	Treatment	1.85	1.30	0	4.5

To address the question, “Is there a difference in *total* I-SBAR CM scores between the treatment and control groups?,” the summed data from the total I-SBAR CM was compared. An independent t-test and Cohen’s *d* were used for this analysis. The homogeneity of variance assumption was met at $p=.326$. The alpha level was set at $.05/2$ or $.025$ for this analysis. There was a significant difference at $t(52)=-3.259$, $p=.002$ between the control group (mean: 4.61) and the treatment group (mean: 6.06). The effect size for

this comparison was $(6.06-4.61)/1.63 = .89$ (95% CI 0.32-1.44). A post-hoc power analysis was calculated at 98.7% based on the result of this large effect.

To address the question, “Is there a difference in *assessment* I-SBAR CM scores between treatment and control groups?” the summed assessment data from the I-SBAR CM was compared. An independent t-test and Cohen’s *d* were used for this analysis. However, the homogeneity of variance assumption was not met at $p=.002$. Therefore, a non-parametric Mann-Whitney U test was performed on the ranked data. The alpha level was set at $.05/2$ or $.025$ for this analysis. There was a significant difference at $p=.015$ between the control (mean rank: 22.57) and treatment group (mean rank: 32.81) with a $U=502$. The effect size (Cohen’s *d*) was $(1.85-1.05)/1.07 = .75$ (95% CI 0.18-1.29).

In summary, significant differences were found between the treatment and control groups for both I-SBAR CM performance scores. This finding leads to the acceptance of the alternative hypothesis; novice health care professional students who participate in a brief designed with a tutored problem score higher on an I-SBAR verbal communication skill compared to peers who received a traditional brief for a given simulation-based learning experience. The magnitude of the differences interpreted according to Cohen’s $U3$ index demonstrates that an effect size of $d=0.89$ for total I-SBAR CM score equates with 82% of the treatment group ($n= .82 \times 26$) or 21 participants scoring above the control group mean. In the case of this study, 7 participants in the treatment group or 27% scored higher due to the intervention. An effect size of $d=0.75$ for assessment I-SBAR CM score equates with 77% of the treatment group ($n= .77 \times 26$) or 20 participants scoring above the control group mean. In this case, six participants in the treatment group or 23% scored higher due

to the intervention. Practical consequences of these results and further interpretation in the context of existing literature are discussed in Chapter 5.

In conclusion the results associated with research question 1 indicate acceptance of the alternative hypothesis. Novice health care professional students who participate in a brief designed with a tutored problem score higher on an I-SBAR verbal communication skill compared to peers who participate in a traditional brief for a given simulation-based learning experience.

4.2 Research Question 2

Two alternative hypotheses were generated from the research question; How does the type and amount of cognitive load reported by novice healthcare professional students compare between those who participate in a brief designed as a tutored problem vs. a traditional brief for a given simulation-based learning experience? The first hypothesis states; Novice health care professional students who participate in a simulation brief designed with a tutored problem experience lower levels of *extraneous* cognitive load compared to peers who participated in a traditional brief for a given simulation-based learning experience. The second hypothesis states; Novice health care professional students who participate in a simulation brief designed with a tutored problem experience similar levels of *intrinsic* cognitive load compared to peers who participated in a traditional brief for a given simulation-based learning experience.

4.2.1 Internal reliability of the Leppink-Paas Scale

Prior to any planned comparisons using data from the Leppink-Paas Scale (Appendix 2), the internal reliability of each part of the tool (intrinsic and extraneous load) and of the tool overall was calculated using a Cronbach's alpha. Items 1-4 on the survey represent the construct *intrinsic cognitive load* and items 5-8 *extraneous cognitive load*.²⁴ Cronbach's alpha is a coefficient of reliability that ranges from 0 to 1 and is a test of unidimensionality and therefore cannot determine separate dimensions in a tool designed to measure more than one concept or construct. Additionally, the greater the number of items included in the tool, the higher the calculated Cronbach, so in this case, the values may be lower than if the tool was made up of more than eight items.¹⁰⁷

The overall Cronbach for the four intrinsic load items (1-4) was calculated at .797. In the analysis, if item 3 was removed, the Cronbach would increase to .832. If any of the other items were removed, the alpha level would decrease. The overall Cronbach for the four extraneous load items (5-8) was .701. If any item was removed from this section of the tool, the alpha level would decrease. When all eight items of the tool were analyzed together, the alpha was .620.

In summary, the alpha values for the two domains of this tool are .7 or greater which meets the threshold considered "adequate," according to Tavakol and Dennick.¹⁰⁷ Because the alpha values for both domains demonstrate adequate levels of internal reliability in the tool as published, there was no reason to remove item 3 from the intrinsic load analysis despite an increase in alpha when doing so. The lower alpha value of .620 for the entire tool, all eight items taken together, may provide support for the tool as a measure of two separate but related constructs.

4.2.2 Between groups comparisons for intrinsic and extraneous load sum

To address the research question, “Is there a difference between groups for the intrinsic load sum and the extraneous load sum?,” the data from the Leppink-Pass survey was compared between the two groups of participants. Fifty-eight participants were included in the analysis. There were 29 participants in the control group and 29 participants in the treatment group. All participants filled out the 8 item Leppink-Paas Survey immediately after completing a simulation encounter. Demographic information by group can be found in Table 4.5.

Table 4.5 Demographic Data

Variable	Group	Description	Frequency
Gender	Control	Female	19
		Male	10
	Treatment	Female	19
		Male	10
Academic Program	Control	DPT	8
		DPM	2
		ABSN	1
		ELMNS	8
		OTD	6
		PA	4
	Treatment	DPT	6
		DPM	4
		ABSN	1
		ELMNS	7
		OTD	6
		PA	5

The descriptive data including means, standard deviations, minimum and maximum scores for both dependent variables, intrinsic load sum and extraneous load sum, can be found in Table 4.6.

Table 4.6 Leppink-Paas summary statistics for each dependent variable by group

Dependent Variable	Group	Mean	Std. Deviation	Minimum	Maximum
Intrinsic Load Sum	Control	13.97	6.14	3	26
Extraneous Load Sum	Treatment	14.76	6.88	0	30
Intrinsic Load Sum	Control	5.83	8.16	0	38
Extraneous Load Sum	Treatment	3.28	5.48	0	20

The data were analyzed using three methods, two parametric methods and one non-parametric method. The first parametric method was an independent student t-test for each dependent variable: intrinsic load and extraneous load, with the alpha level set at .05/2 or .025 for each test. The assumption of homogeneity of variance was met at $p=.665$ for the intrinsic load data and $p=.288$ for the extraneous load data. There was no significant difference found between the treatment group (mean: 14.76) and control group for intrinsic load (mean: 13.97) at $t(56)=-.463$, $p=.645$. Similarly, there was no significant difference between the treatment group (mean: 3.28) and control group for extraneous load (mean: 5.83) at $t(56)=1.398$, $p=.168$.

To provide follow-up to these parametric analyses, a post-hoc power analysis was conducted as the study was not originally powered based on effect sizes of these outcomes. The effect size for the intrinsic load sum was calculated using a Cohen's d as $(14.76-13.97)/6.51=.12$ (95% CI -0.64-0.39). The result of this effect size was a power calculated at .073. The effect size for the extraneous load sum was calculated using a Cohen's d as $(5.83-3.28)/6.82=.37$ (95% CI -0.15-0.88). The post hoc power for this comparison was .288. Cohens $U3$ index demonstrates that an effect size of .12 for ICL can be interpreted as 54% of participants ($n=15$) in the treatment group scored above the mean score for the

control group. This indicates that the treatment and control groups essentially scored the same on ICL. The effect size of .37 for ECL equates to 64 % of participants (n=18) in the treatment group scoring below the mean score for the control group. This equates to 4 participants scoring lower on ECL because of the intervention. Two additional statistical analyses were performed due to the limited power of the initial analysis.

Two non-parametric Mann-Whitney U tests were performed, one for each dependent variable, intrinsic load sum and extraneous load sum. The Mann-Whitney U test is analogous to the parametric t-test. Using a Mann-Whitney U, there was no significant difference in intrinsic load summed mean ranks between the control (mean rank: 28.31) and treatment (mean rank: 30.69) groups at $U=455$, $p=.591$. Also, there was no significant difference in the extraneous load summed mean ranks between the control (mean rank: 33.74) and treatment (mean rank: 25.26) groups at $U=297.5$, $p=.042$.

In summary, there was no significant difference found in the intrinsic load summative scores when Leppink-Pass Survey data were compared between groups. Additionally, despite 19 of 29 subjects in the treatment group and 9 of 29 subjects in the control group reporting 0 for extraneous load, null hypothesis statistical testing found no significant difference for extraneous load between groups. This likely was the result of the low power associated with these comparisons leading to a higher probability of type 2 error or false negative result. These results lead to a rejection of the alternative hypothesis and acceptance of the null hypothesis associated with research question 2. There is no different between levels of intrinsic or extraneous load experienced between novice health care professional students who participate in a simulation brief designed with a tutored problem compared to peers who participated in a traditional brief for a given simulation-

based learning experience. Practical consequences and further interpretation of effect size results for ICL and ECL are discussed in the context of existing literature in Chapter 5.

4.3 Research Question 3

The third research question associated with this study asks, “What is the correlation between the self-reported types of cognitive load, and performance measured by an I-SBAR verbal communication tool for novice health care professional students who participate in a simulation brief designed as a tutored problem vs. a traditional brief for a given simulation-based learning experience?” The alternative hypothesis, “there is an inverse relationship between extraneous load and I-SBAR CM scores for both groups?” and “there is a significant relationship between intrinsic load and total score for both groups?” were analyzed using a Pearson product moment correlation. Fifty-four participants were included in these comparisons, 28 participants in the control group and 26 in the treatment group. There were no significant associations found between extraneous load sum and total I-SBAR CM scores for the group ($r=-.101$, $p=.467$). The post hoc power for this correlation was found to be .111. Using Cohen’s standards for relative size of effect interpreted from correlation, $r=-.101$ would be considered as a small effect. There were no significant associations found between intrinsic load and total I-SBAR CM scores for both groups ($r=.223$, $p=.105$). The post hoc power for this correlation was found to be .363. Using Cohen’s standards for correlation, $r=.223$ would be considered a medium effect size. All correlational data and significance values can be found in Table 4.7. Scatter plots illustrating the data are found in Figure 4.1 and Figure 4.2.

Table 4.7 Correlational results between total I-SBAR scores and summative load scores.

Dependent Variable		I-SBAR Total	Intrinsic Load (Sum Q1-Q4)	Extraneous Load (Sum Q5-Q8)
I-SBAR Total Score	Pearson Correlation	1	.223	-.101
	Sig. (2-tailed)		.105	.467
	N	54	54	54

Figure 4.1. Scatter Plot of Associations Between ICL and Total I-SBAR Scores

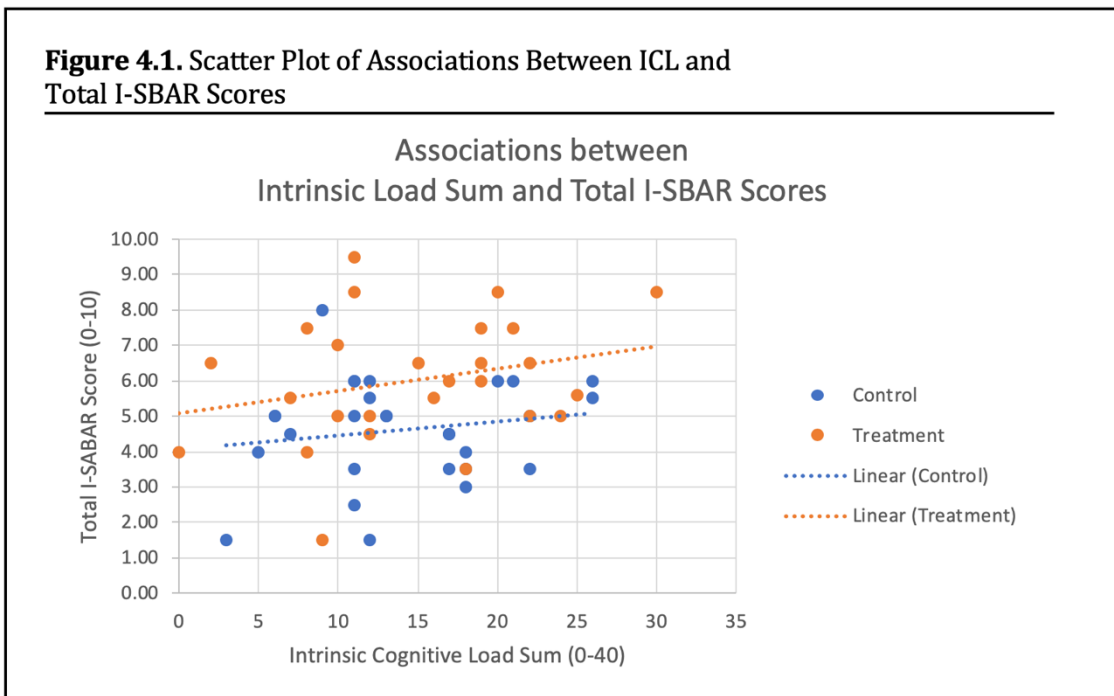
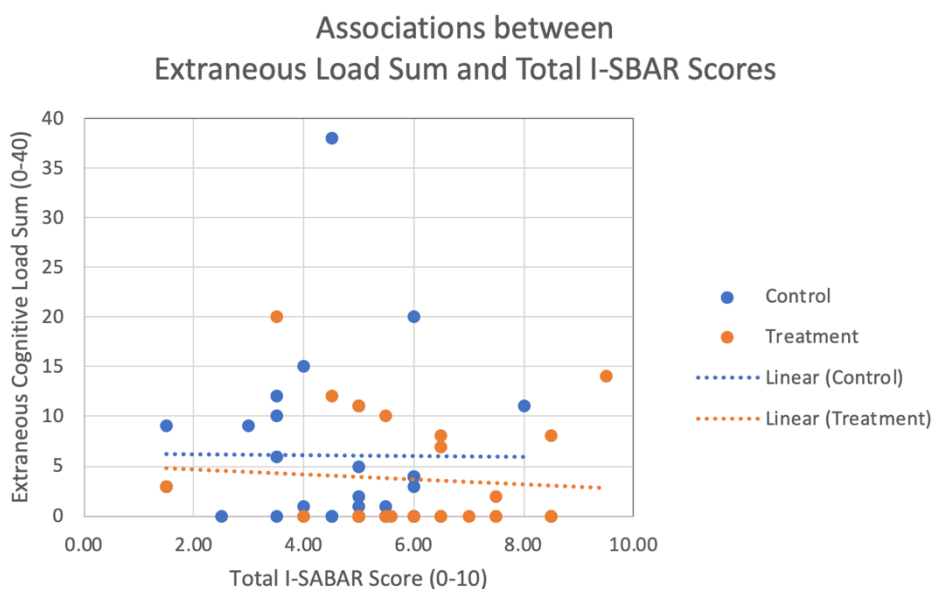


Figure 4.2. Scatter Plot of Associations Between ECL and Total I-SBAR Scores



In summary, there were no significant associations found between intrinsic or extraneous load and total I-SBAR performance scores leading to a rejection of the stated alternative hypothesis. However, interpretation of Pearson’s r as an effect size using Cohen’s standards for correlation indicate a small effect for extraneous load, and a medium effect for intrinsic load between groups consistent with the stated alternative hypothesis. Practical consequences and further interpretation of effect size results for these associations are discussed in the context of existing literature in Chapter 5.

4.4 Research Question 4

The final research question associated with this dissertation was qualitative in nature and asked, “how do novice healthcare professional students in simulation learning experiences interpret the wording of a survey instrument designed to differentiate between *intrinsic* and *extraneous* cognitive load?” The intent was to establish response

process validation evidence for the Leppink-Paas Survey to better interpret the results from comparison and associative analysis. Eleven graduate health professional students participated in individual cognitive interviews. All students were in their second or third year of study and had participated in several simulation experiences during their education. Three students were from physical therapy, two from occupational therapy, two from podiatric medicine, two from the physician assistant program and two from the advanced bachelor's in nursing program (ABSN).

Project text summary analysis is noted as the dominant analysis approach in summarizing cognitive interview data.^{110,112} A recently published guide on the use of cognitive interviewing for survey item development suggests that any analysis be conducted by a team of at least two researchers in order to avoid confirmation bias of the researchers.¹²⁹ For this analysis the PI and an experienced researcher in qualitative methods reviewed transcripts and identified key phrases and relevant statements in response to each verbal probe asked during the cognitive interviews. The key phrases and relevant statements were then summarized into dominant themes by the PI and reviewed by the experienced qualitative researcher. A summary statement and recommendations for any changes to the survey items suggested by the PI was generated for each Leppink-Paas Scale item and presented in table format. Summary statements and associated recommendations are found in Table 4.8 followed by a written summary of the results and recommendations. The cognitive interview transcripts with identified key phrases and relevant statements as well as associated themes are included in Appendix 9.

Table 4.8. Cognitive Interview Text Summary Analysis for Leppink-Paas Scale Items

Leppink-Paas Scale Item	Text Summary Statement/Recommendations
<p>Instructions: All of the following eight questions refer to the activity that just finished. Please take your time and read each of the (8) questions carefully and respond to each of the questions on the presented scale from 0 to 10, in which '0' indicates not at all the case and '10' indicates completely the case.</p>	<ul style="list-style-type: none"> • The 2 ABSN students were not included here as the interviewer mis-read the verbal probe. • Six responders mis-interpreted the word “case” or thought of some other meaning for the word when reading the instructions. The common mis-interpretation is best summarized by the following; <ul style="list-style-type: none"> <i>“I would interpret case as the case that we were like initially given going into the room so like the patient case”</i> • Three responders had correct interpretations summarized by the following; <ul style="list-style-type: none"> <i>“0 indicates not at all the case, so this is to be true or something like not at all true and 10 indicates it is completely true or something.”</i> <p>Recommendation: Health care providers commonly use the word “case” to refer to patient cases. Suggest changing the language from “case” to “true” in the directions when using the survey with health professional students.</p>
<p>1. The content of this activity was very complex.</p>	<ul style="list-style-type: none"> • Seven of the students ascribed difficulty and or familiarity with content to meaning of the word

<p>2. The problem/s covered in this activity was/were very complex.</p>	<p>complex when applied to simulation-based learning. This understanding is best illustrated by the following;</p> <p><i>“something that was like very complex...is more than what I’ve learned already in my program”</i></p> <ul style="list-style-type: none"> • Eight of the students were thinking about multiple elements or components when referring to a complex activity or problem. This understanding is best illustrated by the following; <p><i>“having to kind [of] navigate multiple components of you know like the patient case, such as like monitoring vitals and talking to the patient.”</i></p> <p>Recommendation: Complexity from a cognitive load perspective refers to the number of interacting elements needed to understand a learning activity. Although most students illustrated the understanding of multiple elements equating with complexity, many also thought of complexity as being only something that is difficult or unfamiliar to them. Both constructs link to ICL suggesting no change indicated for these questions</p>
<p>3. In this activity, very complex terms were mentioned.</p>	<ul style="list-style-type: none"> • Seven students defined complex terms as any term they did not understand. • Four students defined complex terms as medical terminology, those that not everyone in society would understand. • One student described complex terms as “like a puzzle, that can be fit together in different ways” <p>Recommendation: similar to questions 1 and 2. Responses link to understanding or knowledge or terms that can have different meaning when combined in different ways. All of which is a component of ICL suggesting no change indicated for question #3</p>

<p>4. I invested a very high mental effort in the complexity of this activity.</p>	<ul style="list-style-type: none"> • Seven student defined high mental effort as having to think about multiple things in order to understand. This is illustrated by the following; <p style="text-align: center;"><i>“I have to string together you know, more than a couple of thoughts to make sense of something.”</i></p> • Two students equated high mental effort with learning or practicing something new or inexperience. Illustrated by the following; <p style="text-align: center;"><i>“I am...not experienced...enough to come up with those things quickly”</i></p> <p>Recommendation: leave statement as is as seven students linked mental effort and complexity to having to think about multiple components to understand.</p>
<p>5. The explanations and instructions in this activity were very unclear.</p>	<ul style="list-style-type: none"> • Students identified unclear instructions as those they had to read more than once or follow up by asking clarifying questions. Instructions that were minimal or vague, or left them not understanding what they were supposed to do were also deemed unclear. <p>Recommendation: leave statement as is.</p>
<p>6. The explanation and instructions in this activity were full of unclear language.</p>	<ul style="list-style-type: none"> • Students understand ‘unclear language’ as not only having to do with comprehension of words and phrases but also having to do with presentation. Word choice, word order, timing and quality of verbal instructions were brought out as causes of unclear language by the participants. <p>Recommendation: leave statement as is.</p>
<p>7. The explanations and instructions in this activity were, in terms of learning, very ineffective.</p>	<ul style="list-style-type: none"> • Students deem explanations and instructions as ineffective in terms of their learning if they are not clearly linked to prior knowledge or familiar context, if they are contradictory, and not presented with simple language or instructor confidence.
<p>8. I invested a very high mental effort in unclear and ineffective explanations and instructions in this activity.</p>	<p>Recommendation: leave statement 7 and 8 as is.</p>

Results indicated that six of nine responders to the verbal probe regarding the survey directions mis-inturpreted the word “case” as referring to the patient case details

and not as intended in terms of referring to agreement with a grading scale. This seems plausible given that health professionals commonly refer a patient “case” as meaning inclusive of all patient details. The suggestion is to change the wording of the directions by substituting the word “true” for “case”.

“All of the following eight questions refer to the activity that just finished. Please take your time and read each of the (8) questions carefully and respond to each of the questions on the presented scale from 0 to 10, in which ‘0’ indicates not at all ~~the case~~ *true* and ‘10’ indicates completely the ~~case~~ *true*.”

Items 1-4 linked to the construct of ICL through the idea of complexity referring to how many interacting elements are required to make sense of a learning activity. For items 1 and 2 most responders illustrated their understanding of a learning activity being complex as having multiple elements or components to keep track of or think about at the same time. Additionally, several also described a learning activity being complex when it was something difficult or unfamiliar to them. These findings are consistent with those identified by Naismith et al.¹⁰³ that prior experience, task complexity and appropriate for level of training relate to ICL in medical simulation environments. It appears that questions 1 and 2 capture these concepts in novice health professional students as written. Item 3 of the survey refers to complex terms mentioned in the learning activity. A majority of responders defined complex terms as those they did not understand which, when considering ICL as a combination of the learner knowledge and the inherent difficulty of the task, a lack of understanding links to ICL. No suggested changes to item 3 are indicated - see table 4.8 for rationale. Item 4 of the survey links mental effort to the complexity of the activity. Most students defined high mental effort as having to think about multiple things

in order to understand, the effort required in practicing something new or their inexperience. All of these concepts relate to the construct of ICL suggesting no needed changes to question 4. These findings are consistent with the findings of Naismith et al.¹⁰³ who identified a lack of prior experience and need to integrate multiple skills as contributing to an increased perception of complexity.

The intent of items 5-8 is to capture the construct of ECL. These 4 items refer to the instructions and explanations associated with different aspects of the learning activity. Responses associated with verbal probes linked to these items suggest that responders had a clear idea of what creates clear and unclear instructions and so no changes to these items are recommended. However, in the simulation environment many instructions and explanations are provided verbally by an instructor. It is interesting to note that the responders to the verbal probes regarding items 5-8 clearly identified the presentation of instructions in terms of word choice, timing of speech, simplicity of language and instructor confidence as key to ensuring clarity of instructions. These themes were not identified by Naismith et al.¹⁰³ and deserve further exploration as potential sources of ECL for learners in SBL. Instructors involved with SBL should be mindful that their mannerisms may unintentionally lead to increased extraneous load in learners.

Chapter 5 Discussion

5.0 Introduction

Within the simulation-based health education literature, there is a call for theory-based, methodologically sound research investigating optimal instructional design strategies for learning.^{5-7,9,60,130} The educational strategies that optimize SBL outcomes remain elusive. Simulation research is at the point where studies designed to manipulate instructional features (such as teaching strategies) are needed to identify best practices for why, how, and for whom simulation-based learning works. This study sought to further this research agenda through the lens of Cognitive Load Theory (CLT) and the associated principle of *example-based learning*. The goal was to investigate the effect of a facilitated tutored problem--a form of example-based learning-- on the performance of verbal communication skills and cognitive load experienced by novice health professional students. The work had three specific aims:

1. to use CLT principles to guide the design of simulation experiences in health professional education to *optimize performance and learning outcomes*,
2. to measure cognitive load in simulation learning environments, and
3. to contribute to the understanding, through the use of simulation, of how best to assist development of health professional students who are ready for collaborative practice.

In this chapter, the implications of the findings associated with this study are discussed in the context of the stated aims. Recommendations for future work are included, followed by

a discussion of the limitations of this work. The chapter concludes with a brief overall summary.

5.1 Implications in the Context of the Stated Aims

Each aim associated with this study will be discussed individually in the context of the research findings associated with this dissertation.

5.1.1 Aim 1: The effect of applying the cognitive load theory principle of the example-based learning to SBL experiences

In reviewing the SBL literature, no studies have formally applied the *example-based learning* principle to test the worked-problem effect in simulation-based learning experiences for novice health professional students. In this study, the brief component of the simulation experience acted as the container for a worked-problem intervention. The intervention brief was designed as a facilitated tutored problem (one type of worked problem). The students in the intervention group were asked a series of open-ended questions to facilitate; 1) bringing forward their prior knowledge and 2) pre-planning their problem-solving strategies prior to the simulation activity. Applying the facilitated tutored problem resulted in a statistically significant between group differences in communication performance ($p=.002$ and $p=.015$) with an associated effect sizes of $d= .89$ (95%CI 0.32-1.44) and $d = .75$ (95% CI 0.18-1.29). These results are consistent with the existing literature on the example-based worked-problem effect for novice learners in traditional classroom learning domains in university settings.

The findings of this research suggest that the worked-problem effect *does* translate to SBL experiences. Results demonstrate that the worked-problem effect in the form of a

facilitated tutored problem can be applied to SBL through adaptation of the brief component of a simulation experience. In this case, a facilitated tutored problem brief proved a viable strategy; it positively affects communication performance outcomes in novice health professional students. Additionally, the magnitude of the effect on immediate post-test performance appears similar to that demonstrated in prior worked-problem literature (when post hoc calculations of effect sizes are compared). The calculated post-hoc effect size for the problem-problem and example-problem conditions in Van Gog et al.⁸⁹ for performance outcomes is $d = .94$ (95% CI 0.28-1.52), (2.66-4.70)/2.18. Similarly, the problem-problem and example-problem conditions in Leppink et al.²⁴ for immediate post-test performance is $d = .68$ (95% CI 0.003-1.30), (5.06-3.50)/2.30. The practical significance of the magnitude of these effects is appreciated when they are compared to the norm for educational intervention effect sizes. According to the U.S. Department of Education, an effect of $d = .35$ is considered the benchmark for comparison in studies manipulating well-planned teaching technique interventions.¹³¹

The results of this study support the use of CLT principles, specifically example-based learning for novices, in designing simulation-based curricular components; this becomes an effective strategy for improving performance outcomes for verbal communication skills, an essential requirement of collaborative clinical practice. If SBL is to continue to emerge and expand as a viable educational modality to assist health professional learners in bridging the gap between academic learning and learning in clinical practice, then educational researchers must pursue studies designed to answer the higher-level questions of *how* and *why* SBL works.

Applying the example-based learning principle through a facilitated tutored problem brief may have facilitated cognitive interactivity in learners. Cognitive interactivity is identified as a best practice for simulation learning; it is typically associated with the debrief component of a simulation experience during which learners are asked to *reflect on* their actions as a strategy to guide or alter future action.⁵ The facilitated tutored problem brief may have provided an opportunity for learners to enhance cognitive interactivity through *reflection before action*. Reflecting before action, with the support of a knowledgeable facilitator, allows novice learners to pull together their discrete knowledge elements, potentially developing more complex schema. Reflection before action has been linked to enhanced self-feedback during and after a simulation activity.⁵⁰ Additionally, the worked example (a facilitated tutored problem brief) from a cognitive load perspective may help decrease unnecessary searching for solutions; in doing so, extraneous load is decreased and working memory resources are freed up to engage in schema construction.¹³² The facilitated tutored problem brief required no additional resources or time; however, it did require an understanding by the facilitator of the theoretical foundation of SBL, as well as an understanding of principles and strategies that support how novice learners learn.

Future research related to this study will focus on how learning outcomes *beyond* performance outcomes are affected by a facilitated tutored problem brief applied to SBL. Additionally, future research applying a facilitated worked problem brief in a group setting is needed to determine if the performance differences, associated with a one-on-one brief as applied in this study, carry over. Ascertaining the effectiveness of this strategy in a group setting is critical; one-on-one instruction is not feasible in typical teaching

environments, given time and instructor resource constraints. Lastly, studies designed to establish an association between stated anxiety level and subsequent performance, in light of a facilitated worked problem brief, may help explain the *why* behind the effectiveness of the strategy.

5.1.2 Aim 2: The Measurement of Cognitive Load in SBL Environments

The ability to measure the type and amount of cognitive load is an essential component of CLT's capacity to guide instructional design.⁹⁷ CLT proposes that working memory load is not the byproduct of the learning process but is a critical factor contributing to the success or failure of an educational intervention.⁹⁷ Capturing differences in cognitive load would better allow educators to adapt learning activities to match the level of a specific group of learners. Understanding how an educational activity affects a learner's working memory, either by intrinsic or extraneous load demands, allows for the relationship between load and performance or learning to be established.^{97,98}

Although this study was not successful in demonstrating an association between cognitive load experienced by novice health professional students and performance outcomes, nor in demonstrating differences between groups in types of load experienced, several contributions to further the measurement of cognitive load in SBL environments resulted. First, this study demonstrated that the internal reliability of each part of the Leppink-Paas Survey appears consistent with that of other studies in classroom and simulation learning environments using the survey.^{24,73} Survey items 1-4 appear to load onto a similar construct, while questions 5-8 load onto a different construct. This provides a degree of validity evidence for using the tool in a simulation context. Secondly, there does

not appear to exist any adverse wording effects associated with the tool. Response process results from cognitive interviews with novice health professional students indicate that, from a qualitative standpoint, the items appear to capture the constructs of ICL and ECL as intended. Obtaining response- process evidence is a strength of this study; the medical education research community has identified validation evidence of this type as necessary in the development of high-quality questionnaire and survey tools. Naismith et al.¹⁰⁵ concluded that, in 48 studies attempting to measure cognitive load in medical simulation training, *none* had reported response process validation evidence. In this study, collecting response process data provides an additional measure of validity evidence for using the Leppink-Paas Survey with health professional students in SBL activities.

However, even if the Leppink-Paas Scale appears to capture ICL and ECL, the tool may not capture cognitive load imposed on working memory from the actual simulation environment.¹³³ Choi et al.¹³³ present a compelling argument calling for the *physical* learning environment to be treated as a separate factor influencing cognitive load and learning in addition to the learning task and the learner. This new conceptualization of the causal factors of load creates four distinct interactions between the physical environment, learning task, and learner that must all be considered when attempting to quantify the amount and type of cognitive load experienced by learners in SBL activities. Support for this argument was found through analysis of the cognitive interview results associated with this study. Participants in this study identified instructor mannerisms such as voice tone, quality, and a lack confidence as possible factors contributing to their ECL in a simulation learning environment. According to Choi et al.¹³³, the instructor and all associated mannerisms are considered a component of the physical learning environment.

One other explanation for the lack of difference between groups, in terms of ECL experienced, is suggested by the work of Naismith et al.¹⁰³ These authors identified anxiety, fidelity, and the degree to which a given simulation activity focused on assessment rather than formative practice as components of extraneous load specific to SBL in medical education. These components do not appear to be captured by the Leppink-Paas Scale, suggesting that scores for ECL in this study may be lower than the ECL actually experienced by some participants. Adapting existing tools, as well as creating new tools specific to capturing cognitive load specific to SBL environments, is an important area for continued research.

Lastly, the lack of significant associations between load type and performance, and between group differences for load type, were unexpected. CLT would suggest that students who experienced the tutored problem brief would experience lower levels of extraneous load; as a result, one would expect slightly lower levels of intrinsic load if the tutored problem supported schema construction prior to the simulation activity.¹⁵ The probable explanation for the findings in this study is most likely the result of a Type 2 error, due to an inadequate sample size for these associations and comparison. The study as a whole was powered based on effect sizes for the worked-problem effect comparisons, but not for determining differences in cognitive load type or correlations between load type and performance. Post hoc power analysis for the ICL and ECL comparisons (.07 and .29 respectively) reveal the study was significantly underpowered to capture these differences if they did indeed exist. Leppink et al.²⁴ found similar results: the example-problem condition did not differ from the problem-problem condition, in terms of ICL and ECL, when measured at the time of the post-test. The post-hoc power analysis calculated

for both the ICL and ECL comparisons between the example-problem and problem-problem groups was also insufficient at 0.11. Additionally, Leppink et al.²⁴ provide two alternative explanations:

- the acquisition or learning phase may have been too short to significantly affect intrinsic or extraneous load in novice learners, or
- the beneficial effects of the worked problem may have been captured by a different construct related to knowledge and understanding.

At the same time, Trembley et al.⁷³ did find significant differences for both ICL and ECL between complex and simple tasks in a simulation environment; however, these differences were within-group differences rather than between-group. In summary the Leppink-Pass Survey appears to have adequate internal and response process validation evidence for use with novice health professional students in a simulation learning environment. Given that levels of ECL captured by the Leppink-Pass Survey in a simulation activity may be lower than the ECL actually experienced by learners, additional concepts (identified by Naismith et al.¹⁰³ and from this study) relating to possible ECL contributors specific to SBL environments must be considered. Lastly, future between-groups studies will need to be powered accordingly, with samples likely in excess of 100 participants, in order to capture a significant between-groups difference for ICL and ECL that would demonstrate a moderate effect as the result of a teaching intervention. An increase in sample size will also allow for further confirmatory factor analysis in a simulation learning context.

5.1.3 Aim 3: Facilitating Development of Health Professional Students Ready for Collaborative Practice

A marker of collaborative practice is strong interprofessional communication among providers. Poor communication continues to result in preventable medical errors; this demonstrates the need for health professional educators to focus curricular efforts on interprofessional communication outcomes.¹³⁴ Studies have demonstrated that using a standardized structure for communication, such as that provided by the SBAR tool, improves quality and patient outcomes, the climate of safety in the workplace, and reduced incident report filings in clinical settings.³³⁻³⁵ Using the I-SBAR tool in simulated environments has also been successful in improving the communication skills of health professional students. This validates the need for faculty to evaluate learners' communication performance while in simulation.³⁶

In this study, the SBAR tool was intentionally chosen as the standardized communication outcome measure. All students had been exposed to the SBAR structured communication tool during their program course work. All students had limited practice using the tool in real or simulated settings. Results of this study demonstrate that novice health professional students' performance on this critical IPEC core competency – communication – was significantly improved when a facilitated worked-problem brief was implemented. The results demonstrated that the intervention group was able to include greater overall detail in their verbal communications, as well as provide more accurate recommendations for care to other providers. It is hoped that these performance improvements in simulated environments translate to behaviors carried forward into practice.

Capturing the transfer of performance improvements demonstrated through SBL to behaviors applied in real practice remains elusive; it will require the continued attention of the educational research community. However, in order to optimize the potential for learning through simulation that will translate to practice, faculty must be aware of educational theory and its resulting evidence based-educational principles. Additionally, continued research that applies contemporary educational theory to simulation design should continue, as this work demonstrates that promising outcomes can result.

5.2 Delimitations and Limitations

One clear delimitation of this study was the inadequacy in sample size for several planned comparisons, specifically those comparing ICL and ECL levels between groups and those determining associations between ICL and ECL and performance outcomes. The study was powered to find a worked-problem effect similar in magnitude to that reported in the literature and was successful in finding results in line with those studies.^{24,89} Determining if the worked-problem effect translated to a simulation learning activity was the primary research question of this dissertation; thus, the decision to base sample size on this known effect was appropriate. However, the secondary research questions to establish if the Leppink-Pass Survey can differentiate load type between groups receiving different educational interventions, as well as determining if the load type experienced correlates to performance outcomes, are important to understanding how best to design SBL experiences. Further study is needed to gain insight into this area. What has been established is that these types of studies most likely require sample sizes upwards of 100 participants.

Additionally, non-probability convenience sampling was used, which may have led to

self-selection bias. For example, those who volunteered may have been comfortable with participating in simulation activities and therefore might have performed better on the task than would those who did not volunteer. This type of sampling was chosen largely for logistical reasons and potential ease of recruitment. A method to avoid this risk of bias in the future may be to use purposive sampling and recruit an entire class or cohort of a particular health profession.

The I-SBAR Communication Measure can also be considered a delimitation in that it was developed by the PI and reviewed by several faculty from programs across Samuel Merritt University. The revision process included informal discussions and comments that led to changes in the initial version of the instrument. However, the I-SBAR Communication Measure has not undergone any formal psychometric analysis; therefore, scores can be judged solely on the validity and reliability evidence presented in the discussion. The decision was made to create a new measure after an extensive search by the PI failed to uncover an existing verbal communication tool for use in SBL environments from which an objective score could be generated. Subjecting this newly created tool to more formal psychometric analysis is appropriate for its continued use in future studies.

In terms of the simulation brief intervention, some may suggest that the PI providing the treatment intervention and control intervention for all participants was a limitation. This was done to ensure a degree of consistency in applying the intervention across both groups. To control for possible bias in the delivery of the intervention, both interventions were guided by a predetermined scripted outline. Additionally, the PI providing the intervention for all participants did not interfere with the double-blinding of the study since the individual scoring the communication outcomes was not involved with the

planning the actual simulation activities of the study. This individual was also blinded to the group assignments (control vs. intervention) of the participants. Lastly, the participants were blinded to their participation in the control vs. treatment group.

The SBL activity for this study included use of a manikin rather than a standardized patient. This was by choice for novice health care professional students from various programs at a single university. A manikin provides a lesser degree of fidelity than a standardized patient (SPs), creating a lesser degree of realism with the intentional ability to better control ICL influences on the participants. Additionally, the associated costs and logistics limited the use of SPs in this study. In future studies the use of SPs would be an appropriate means of potentially altering levels of ICL and ECL as one might expect from a more realistic environment.

Generalizing the impact of the tutored-problem brief intervention across students and universities requires comment. It is important to note that this series of studies was conducted at a single university, in one simulation center, with a sample of students who all had similar training in a form of communication structured around the Team STEPPS model. All had prior experience to some degree with SBL in an immersive environment, either independently or in small groups. However, the PA students had only experienced simulation with standardized patients, never with manikin-based simulation. The sample represented students from five different graduate programs in the health professions, which affected the timing of the students' Team STEPPS training (when it had occurred in relation to when the study took place). The level of reinforcement of the I-SBAR tool after training most likely varied among programs and possibly affected the students' level of recall and familiarity with the I-SBAR model. All students were considered "novice" based

upon the limited time spent as fulltime (two weeks or less) students in a clinical setting; this limited their exposure to Team STEPPS-like communication between providers, as well as the opportunity to practice in a clinical setting. However, students in several programs had been to clinic for several one-week experiences, while students in other programs had yet to experience any clinical time. Regardless, the randomization process likely controlled for many of these confounding variables. Additionally each student was provided a tutored-problem brief, which allowed the student individualized instruction in a safe environment tailored to their specific learning needs. In classes with large numbers of students, the brief component of a simulation experience is typically presented to small or large groups of students and as is affected by the availability of resources, including time. It would be interesting to perform a similar study with the tutored-problem brief presented to small and large groups of students to ascertain if the resulting performance effects are similar to those of this study.

5.3 Implications for Today's Health Professions Educator

The findings of this research suggest that the worked-problem effect *does* translate to SBL experiences. Health professions educators across disciplines can use the evidence generated from this study to effectively teach their students through simulation. By rethinking the purpose and therefore design of the brief component of a typical simulation activity, educators can assist their students in achieving improved performance outcomes.

The evidence suggests that when facilitating a simulation experience for students with novice level experience or understanding in a context, that some sort of guided reflection-before-action in the form of a facilitated tutored problem should take place.

Specifically, educators should be asking open-ended guiding questions of these students as part of the brief component. These questions are intentional in helping students bring their knowledge in pieces together in the context of working through the forthcoming simulation encounter. This process may; 1) help students develop more complex long-term memory schema, 2) decrease extraneous load by clarifying confusion in instructions as well as expectations and 3) provide an opportunity for self-reflection on individual potential problem areas as well as provide time to work out a solution, all prior to a simulation encounter. Examples of guiding questions might be:

- After reading the objectives and goals, and reviewing the case and simulation environment do you have any questions I can answer?
- What are you most concerned about in terms of achieving the goals and objectives of this experience?
- What are you unsure about in terms of your own knowledge and understanding that you think will limit your performance in the encounter?

These questions serve to open the door for further exploration in that as a facilitator the educator is not telling the student the answer, but asking further questions in helping them find their own solution. Being intentional with open ended questioning during the brief can serve as a facilitated tutored problem and have the potential to improve student performance on simulation based learning outcomes.

5.4 Summary

Recent systematic review of the efficacy of SBL in the health professions strongly suggest the research community no longer ask if learners: are satisfied with their

simulation experiences; value simulation as a learning tool, or; have increased confidence because of their simulation experiences.^{3,6} We have ample evidence to suggest these questions have been answered across the health professions. Despite this call for higher-level studies answering questions of how and why simulation works, health professions education literature continues to focus on outcomes of student perception. For example, in the recent physical therapy literature, simulation outcomes have focused on student confidence, student attitudes towards IPE, students' perceived readiness for clinical education, and student self-efficacy for practice.¹³⁵⁻¹³⁸ Each of these studies was well executed but provided answers to questions already answered by other health professions. There is value in ascertaining if similar results are shared among the health professions. Limited time and resources suggest our focus should shift toward answering these questions:

- How does simulation best work as a learning strategy?
- What techniques are best used for a given level of learner?
- What is the rationale for using a particular instructional design?

Cognitive Load Theory is a well-developed theoretical framework that provides significant contributions to health professional educational research. The framework is applicable to simulation-based learning, as attending to working memory and the strategies of managing cognitive load are highly relevant in the development of future health professionals. When learners' or clinicians' working memory is overloaded, performance is impaired, errors occur, and patient harm may result. The application of CLT principles to simulation design intervention studies, such as the worked- problem effect

explored through this dissertation, should continue. Additionally, the development of more accurate measures of cognitive load subtypes experienced during simulation-based learning, or the refinement of existing measures, also must continue. By understanding how teaching can maximize learning by increasing our understanding of the learning process, we contribute to the scholarship of teaching and learning. This understanding will allow health professions' educators to better design simulation-based learning curricula that truly demonstrate optimal performance and learning outcomes for our students and, as a result, ultimately increase patient safety.

Appendix 1: Simulation Experience Learning Objectives

Simulation experience learning objectives - based on IPEC core competencies

1	Use the I-SBAR communication tool to facilitate interactions that enhance team function.
2	Communicate information with patients and health team members in a form that is understandable, avoiding discipline-specific terminology when possible.
3	Express one's knowledge and opinions to team members involved in patient care with confidence, clarity, and respect, working to ensure common understanding of information, treatment, and care decisions.
4	Use respectful language appropriate for the situation and crucial conversation.

Appendix 2: Leppink-Paas Scale

All of the following eight [8] questions refer to the activity that just finished. Please take your time to read each of the questions carefully and respond to each of the questions on the presented scale from 0 to 10, in which '0' indicates not at all the case and '10' indicates completely the case:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

[1] The content of this activity was very complex. _____

[2] The problem/s covered in this activity was/were very complex. _____

[3] In this activity, very complex terms were mentioned. _____

[4] I invested a very high mental effort in the complexity of this activity. _____

[5] The explanations and instructions in this activity were very unclear. _____

[6] The explanation and instructions in this activity were full of unclear language. _____

[7] The explanations and instructions in this activity were, in terms of learning, very ineffective. _____

[8] I invested a very high mental effort in unclear and ineffective explanations and instructions in this activity. _____

Leppink, J., Gog, T., Paas, F. and Sweller, J. (2015) Cognitive load theory: researching and planning teaching to maximize learning, in Researching Medical Education (eds J. Cleland and S. J. Durning), John Wiley & Sons, Ltd, Chichester, UK. doi: 10.1002/9781118838983.ch18

Appendix 3: Verbal Recruitment Solicitation—Cognitive Interview

Hello,

Thank-you for allowing me time in your class today. I have consulted with your faculty _____, and they have allowed me to solicit participants into a study as part of my dissertation work titled: Interpretation of a Cognitive Load Survey for use in Simulation Based Learning: A Validation Study Using Cognitive Interviewing

Read in place of the above paragraph if you are not the PI

Thank-you for allowing me time in your class today. Your faculty _____, has allowed me several minutes of class time to solicit participants into a study titled: Interpretation of a Cognitive Load Survey for use in Simulation Based Learning: A Validation Study Using Cognitive Interviewing.

The purpose of this initial study is to determine how you as novice learners in graduate health professional education interpret the wording in a series of questions on a survey designed to measure your cognitive load/mental effort experienced during a simulation activity.

Understanding this may help educators design simulation experiences that more specifically optimize the experience for your learning.

The study involves approximately 5-7 minutes to answer the 8 survey questions followed by an additional 15-20 minutes in a one on one interview with an experienced interviewer who is not one of your programs' faculty. During the interview you will be asked a series of questions about how you interpreted the wording of the questions on the survey. The interviews will be audio-recorded only to allow for transcription.

Survey completion and interviews will occur during your assigned formative simulation experience on _____.

If you are interested in possibly volunteering as a participant in this study, please contact me by email at sgrieve@samuelmerritt.edu and I will contact you with further information.

Read in place of the above paragraph if you are not the PI

If you are interested in possibly volunteering as a participant in this study, please contact Dr. Susan Grieve by email at sgrieve@samuelmerritt.edu and she will contact you with further information.

Again, thanks for your time today.

Note: Copies of this same solicitation will be left after reading aloud for any potential participant to have

Appendix 4: Brief Participant Data Collection Form – Cognitive Interview

Inclusion/Exclusion Criteria Check off for Study 1 Participants - Cognitive Interview

Name and Contact Information	Age ≥ 21	Program	Year in Program	Full-time experience as a health care provider

Appendix 5: Informed Consent –Cognitive Interview

Informed Consent SMU Consent to be in a Research Study Entitled

*Establishing Response Process Validation Evidence Using the Cognitive Interview for a
Measure of Cognitive Load*

Who is doing this research study?

Principal Investigator: Susan Grieve, DPT, MPT, MS
Department: Physical Therapy
Institution: Samuel Merritt University
Contact: 510.879.9200 x 7384, sgrieve@samuelmerritt.edu

Faculty Advisor/Dissertation Chair: Shari Rone-Adams, PT, MHSA, DBA
Nova Southeastern University, Department of Physical Therapy, College of Health Care
Science, Health Professions Division. Fort Lauderdale FL.

Co-Investigator(s): None

Site Information: Health Science Simulation Center Samuel Merritt University, 450 30th Street
Oakland, CA 94609

Funding: Unfunded

What is this study about?

This is a research study, designed to test and create new ideas that other people can use. The purpose of this research study is to **determine how novice learners in graduate health professional education interpret the wording in a series of questions on a survey designed to measure the type and amount of mental effort (cognitive load) experienced during a simulation activity. Understanding the type of mental effort (cognitive load) experienced during a simulation may help educators better design simulation experiences to optimize the experience for learning.**

Why are you asking me to be in this research study?

You are being asked to be in this research study because you are enrolled as a student one of the following graduate health professional programs at Samuel Merritt University; Doctor of Physical Therapy, Doctor or Master of Occupational Therapy, Entry Level Master of Nursing Science, Master of Physician Assistant or Doctor of Podiatric Medicine.

This study will include about 10-12 people. It is expected that all 10-12 people will be enrolled in the study from the Samuel Merritt University campus in Oakland California.

What will I be doing if I agree to be in this research study?

While you are taking part in this research study you will be asked to participate in one session for approximately 30-40 minutes.

Research Study Procedures - as a participant, this is what you will be doing:

At the end of a formative simulation activity associated with a regularly scheduled course you are enrolled in at SMU you will be escorted to an interview room to fill out a survey made up of eight questions. This should take 5-7 minutes. When finished you will join the rest of your class for any scheduled formal debrief regarding the simulation experience. You will then be escorted back to the interview room and participate in a *cognitive interview* with a faculty member that is not one of your programs' faculty. The interview will take 15-20 minutes and will be audio recorded. Your interviewer will begin by reading you an introduction to what you will be doing and allow you to ask and have answered any questions before the recording begins. They will inform you of when the recording will begin. During the interview you will be asked a series of questions designed to have you think about the words and phrases that made up the survey you filled out earlier. You will be able to refer to your survey at any time during the interview and may ask any clarifying questions. The interviewer may also ask questions to clarify your answers and write a few notes. There are no right or wrong answers to these questions. When the interview is completed the interviewer will let you know the recording has been turned off. This will mark the end of your participation and you will be offered a \$5.00 coffee shop gift card for your time.

In the event that there are two participants to be interviewed and only one interviewer available, you may be asked to wait and additional 15-20 minutes at the end of the simulation experience before your interview begins.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You have the right to leave this research study at any time, or not be in it. If you do decide to leave or you decide not to be in the study anymore, you will not get any penalty or lose any services you have a right to get. If you choose to stop being in the study, any information collected about you **before** the date you leave the study will be kept in the research records for 36 months from the conclusion of the study, but you may request that it not be used.

What if there is new information learned during the study that may affect my decision to remain in the study?

If significant new information relating to the study becomes available, which may relate to whether you want to remain in this study, this information will be given to you by the investigators. You may be asked to sign a new Informed Consent Form, if the information is given to you after you have joined the study.

Are there any benefits for taking part in this research study?

There are no direct benefits from being in this research study. We hope the information learned from this study will help you be more aware of the mental efforts (cognitive load) you experience during a simulated learning activity. This awareness may help you better learn from these types of learning activities.

Will I be paid or be given compensation for being in the study?

You will be given a \$5.00 Starbucks coffee gift card when you have completed your cognitive interview before you leave the simulation center. The gift card will not be pro-rated if you do not complete the interview.

Will it cost me anything?

There are no costs to you for being in this research study.

Ask the researchers if you have any questions about what it will cost you to take part in this research study (for example bills, fees, or other costs related to the research).

How will you keep my information private?

Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law and will be limited to people who have a need to review this information. The audio recordings or your interview and survey results will be kept in the locked office of the principle investigator (PI) at Samuel Merritt University (SMU). Once the audio recordings are transcribed they will be deleted permanently from the recorders. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any regulatory and granting agencies (if applicable). If we publish the results of the study in a scientific journal or book, we will not identify you. All confidential data will be kept securely in a locked file cabinet in the PI's office at SMU. This will include hard copies of the transcribed recordings as well as electronic data files on a designated flash drive. All data will be kept for 36 months and destroyed after that time by placing the hard copy transcribed interviews and survey sheets in a university paper shredder and deleting any files stored on the flash drive.

Under California law, the privilege of confidentiality does not extend to information about sexual or physical abuse of children or the elderly. If a researcher has or is given such information, he or she will be required to report it to authorities. The obligation to report includes alleged or probable abuse as well as known abuse.

Will there be any Audio or Video Recording?

This research study involves audio recording. This recording will be available to the researcher, the Institutional Review Board and other representatives of this institution will be kept, stored, and destroyed as stated in the section above. Because what is in the recording could be used to

find out that it is you, it is not possible to be sure that the recording will always be kept confidential. The researcher will try to keep anyone not working on the research from listening to the recording. The recording once transcribed will be deleted from the recorder and your name will not appear on your transcribed interview.

What Student/Academic Information will be collected and how will it be used?

We will ask you if you are enrolled at least as ½ status at SMU as well as program you are associated. We will not confirm your answers with the registrar.

Whom can I contact if I have questions, concerns, comments, or complaints?

If you have questions now, feel free to ask us. If you have more questions about the research, your research rights, or have a research-related injury, please contact:

Primary contact:

Susan Grieve, PT, MS, DPT can be reached at 510.879.9200 x 7384,
sgrieve@samuelmerritt.edu.

If primary is not available, contact:

Gail Widener PT, PhD Chair, Samuel Merritt University Institutional Review Board for the Protection of Human Subjects (SMUIRB) can be reached at 510-879-9200 x 7378,
GWidener@samuelmerritt.edu

Shari Rone-Adams PT, MHSA, DBA Committee Chair can be reached at (954) 262-1740. Please note Dr. Rone-Adams is located in Florida which is 3 hrs ahead of California time.

Research Participants Rights

The rights stated below are the rights of each person who is asked to be in a research study. As an experimental subject, I have the following rights:

1. To be told what the study is trying to find out;
2. To be told what will happen to me and whether any of the procedures, drugs, or devices is different from what would be used in standard practice;
3. To be told about the frequent and/or important risks, side effects, or discomforts of the things that will happen to me for research purposes.
4. To be told if I can expect any benefit from participating, and, if so, what the benefit might be;
5. To be told of the other choices I have and how they may be better or worse than being in the study;
6. To be told what sort of medical treatment is available if any complications arise;
7. To refuse to participate at all or to change my mind about participation after the study is started. This decision will not affect my right to receive the care I would receive if I were not in the study;
8. To receive a copy of the signed and dated consent form;
9. To be free of pressure when considering whether I wish to agree to be in the study.

All space below was intentionally left blank.

Research Consent & Authorization Signature Section

Voluntary Participation - You are not required to participate in this study. In the event you do participate, you may leave this research study at any time. If you leave this research study before it is completed, there will be no penalty to you, and you will not lose any benefits to which you are entitled.

If you agree to participate in this research study, sign this section. You will be given a signed copy of this form to keep. You do not waive any of your legal rights by signing this form.

SIGN THIS FORM ONLY IF THE STATEMENTS LISTED BELOW ARE TRUE:

- You have read the above information.
- Your questions have been answered to your satisfaction about the research.

Appendix 6: Instructions for Interviewers – Cognitive Interview

- You are being asked to interview graduate health professional students for 15-20 minutes to ascertain how they interpret the wording on a survey designed to measure different sub-types of cognitive load.
- This measure has been derived and subjected to collection of some validation evidence in classroom learning environments with both graduate and undergraduate students in statistics and language classes.
- The measure has not ever been used as a tool to capture cognitive load experienced by graduate health professional students nor from simulated learning activities.
- The intent of data collection is to provide a degree of response process validation evidence from which scores on the measure used in a future planned study can be interpreted.

- The interviews are designed as a cognitive interview and follow a very structured format.
 - The student will be escorted to the interview room and you will introduce yourself and provide the student with the actual Leppink Scale they scored immediately after their simulation experience.
 - You will then read the introduction to the student (Appendix 7) included in this packet to the student and ask if they have any questions.
 - When ready please turn on the recorder and begin the interview reading the first cognitive probe (Appendix 8). Proceed through all questions in order.
 - Once the student has completed an answer to a question, you may wish to ask a follow-up question for clarification but please keep these as minimal as possible and record any notes on the verbal probe questions sheet that you deem appropriate.
 - Once all verbal probe questions have been answered please inform the participant that the interview is completed and turn off the recorder.
 - Please provide a \$5.00 coffee shop gift care to the participant.

Appendix 7: Introduction for Participants – Cognitive Interview

- Thank-you for agreeing to participate in this interview. The interview is called a cognitive interview as the questions I am going to ask you are designed to allow the researcher insight into how you interpret some of the words and phrases on the survey you filled out at the end of the simulation experience.
- The interview should not take any longer than 15-20 minutes.
- You have the survey you filled out in front of you and you can refer to it at any time. I may also ask you to refer to a specific question on the survey when asking you a question.
- You can ask me if you need any clarifications regarding the questions I ask you and I may ask you to clarify your answers as well.
- It is important to understand that there are no right or wrong answers to these questions - we are asking you for your interpretation.
- The interview will be audio recorded and I will let you know when we start recording as well as when we end recording.
- At the end of the interview I will give you a coffee card as an appreciation for your time.
- Once the audio recordings are transcribed they will be erased.
- Do you have any questions? Are you ready to begin?
- Ok - I'm going to turn on the recording now.

Appendix 8: Verbal Probes/Data Collection Worksheet – Cognitive Interview

Scripted Probes	Ref. Q	Notes: as needed
<p>1</p> <p>In reading the instructions for the questionnaire, how do you interpret the meaning of the word “case” in “0 indicating not at all the <i>case</i> and 10 indicating completely the <i>case</i>”</p>		
<p>2</p> <p>What do the words “complex” and “complexity” mean to you when applied to simulation-based learning activities?</p>	Q1-4	
<p>3</p> <p>What specifically were you thinking of or about when rating the statements in the questionnaire that used the terms “complexity” or “complex”?</p>	Q1-4	
<p>4</p> <p>In Q3 the phrase “complex term” is used. How would you define a “complex term”?</p>	Q3	

5	In Q4 the phrase “high mental effort” is used. How do you define “high mental effort”?	Q4	
6	How do you determine if explanations and instructions are “unclear”?	Q5	
7	What makes language unclear for you?	Q6	
8	How do you determine if explanations and instructions are “ineffective” in terms of contributing to your learning?	Q7	
9	In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? This includes the brief, actual activity as well as the debrief.	Q8	

Appendix 9: Project Text Summary Analysis – Cognitive Interview

Verbal probes with transcription by participant. Key phrases, relevant statements extracted, and themes notated. KEY: S = Subject, R = Researcher		
Verbal Probe 1: In reading the instructions for the questionnaire, how do you <i>interpret</i> the meaning of the word “case”, in the phrase “0 indicating not at all the <i>case</i> and 10 indicating completely the <i>case</i> ”		
Leppink-Paas Scale reference statement: Instructions	Key phrases/Relevant Statements	Themes
PA-01 S: I interpreted the word “case” to refer to the entire uhm page of information that I received from uhm as far as background information for the patient as well as the simulation inside the room R: Okay S: And the debriefing R: Okay	<ul style="list-style-type: none"> the entire uhm page of information that I received as well as the simulation inside the room 	<ul style="list-style-type: none"> Case as patient information
PA-02 S: Uhm, so the word “case” you said? R: Mhmm, the word “case” in this phrase S: I, I interpret that as uhm zero is that this phrase is uhm not true. R: Mhmm, [short pause] and ten indicating? S: That this phrase is, is true or is uhm R: Mhmm, okay S: Yeah, I think [chuckle]	<ul style="list-style-type: none"> I interpret that as uhm zero is that this phrase is uhm not true That this phrase is, is true 	<ul style="list-style-type: none"> Case as a rating scale
OT-01 S: I’d say nine? R: So uhm, how do you, but how do you interpret the meaning of the word “case” when its been referred to uhm in that sentence? S: I think of “case study” as a situation with the patient R: Okay	<ul style="list-style-type: none"> I think of “case study” as a situation with the patient 	<ul style="list-style-type: none"> Case as patient situation – patient information
OT-02 S: Oh, uhm, so the word case? R: Mhmm S: On here? Oh...right here R: Yeah, right here in the instructions. Yep. S: Uhhh I would say nine R: And, and how do you interpret the word “case” though? S: Oh! I interpreted it.. well I knew that it was because of the simulation activity. But I think seeing the word case, I think of like something to carry. That’s what my, visually that’s	<ul style="list-style-type: none"> I interpreted it.. well I knew that it was because of the simulation activity. But I think seeing the word case, I think of like something to carry. That’s what my, visually that’s 	<ul style="list-style-type: none"> Case as patient information or unintended visual of suitcase

	<p>what came to my mind first R: Like a suitcase? S: Yeah, like a suitcase [both chuckle] R: And then, but when you interpret the meaning of the word case, in this particular phrase, you thought of the simulation? S: Yeah R: Okay S: Yeah, the simulation</p>		
DPT-01	<p>R: So right here in these instructions, how do you interpret the word "case"? S: Uhhmm, I would interpret case as the case that we were like initially given going into the room so like the patient case R: Ok</p>	<ul style="list-style-type: none"> • I would interpret case as the case that we were like initially given going into the room so like the patient case 	<ul style="list-style-type: none"> • Case as having to do with patient information
DPT-02	<p>R: So that's right in here. S: So, I interpret the case as meaning both the, the written part and the simulation experience.</p>	<ul style="list-style-type: none"> • the written part and the simulation experience 	<ul style="list-style-type: none"> • case as patient information

DPT-03	<p>R: So right in here, in these instructions</p> <p>S: Uhhh [long pause] So, not in this instance? In, in the, this circumstance, is that what you mean?</p> <p>R: No, so in reading the, how do you interpret the word case, so what do you thi, how do you interpret</p> <p>S: Not at all the case</p> <p>R: So, yeah</p> <p>S: And 10 indicates completely the case</p> <p>R: So what, how do you interpret the word case</p> <p>S: Uhm</p> <p>R: In this sentence</p> <p>S: Like, in this situation?</p> <p>R: Mhmm</p> <p>S: That's what I'm saying is the case</p> <p>R: Oh ok ok I'm sorry</p> <p>S: Like [chuckles] like, uhh not at all the case, I don't know. My vocabulary is maybe bad [chuckles]</p> <p>R: No, no</p> <p>S: Uhm, 0 indicates not at all the case, so this is to be true or something like not at all true and 10 indicates it is completely true or something</p> <p>R: It is completely the case, so what, what is what do you think was the case? What do you uhm was the case uhm what she gave you? or what you, what you went into?</p> <p>S: Oh!</p> <p>R: What was the word uhm how do you interpret the word case</p> <p>S: Not at all..</p> <p>R: In this phrase</p> <p>S: Ok</p> <p>R: So</p> <p>S: Well, ok, all of the following question refer to the activity just, that just finished, please take your time to read each of the questions carefully and respond to each of the questions on the presented scale from 0 to 10. In which 0 indicates not at all the case and 10 indicates completely the case. And so, zz, like zero so not at all the case</p> <p>R: Right</p> <p>S: So, so if, so if the question is uhm so the content of the activity was</p>	<ul style="list-style-type: none"> • 0 indicates not at all the case, so this is to be true or something like not at all true and 10 indicates it is completely true or something 	<ul style="list-style-type: none"> • Case as a rating scale
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	<p>very complex and I put four so I don't think that, the case R: So you, so you don't think S: Was complex. Ok, so I see what you're saying. So I, yes, yeah that situation is the case R: Ok S: [laughs] R: Uhm, but I also, I want to be sure I understand what you're first interpretation was, so you're not at all the case? Not at all to be true or not at all, is that what you're referring to as the case? So this is that, is 0 it's it's not at all the case S: Yeah R: Not at all the case, I think you said to be true S: Yeah R: Ok, S: That's what I R: That's fine, there's two ways of interpreting this right? So, ok S: You were asking for clarification so I was confused R: Ok, right, but that's, so ok yeah, good</p>		
DPM-01	<p>R: So, it's this, these instructions right up here S: okay R: How do you interpret the meaning of the word "case"? S: Uhhh, I guess, like I thought of it like, if I read it in my own head, I would say like, "oh this indicates not at all this situation or like uhm or if I agree with it or not. I guess, like situation is what I think about it R: the situation? S: Yeah R: Okay</p>	<ul style="list-style-type: none"> • I would say like, "oh this indicates not at all this situation or like uhm or if I agree with it or not. 	<ul style="list-style-type: none"> • Case as a rating scale

DPM-02	<p>R: So this particular uhm sentence, that phrase, uhm how do you interpret that?</p> <p>S: Uh, [long pause] So assuming zero is from not at all and ten is indicating</p> <p>R: mhmm but how do you interpret the word "case" that is used in that phrase?</p> <p>S: Oh, case I'm thinking that it was an activity</p> <p>R: The activity that you were going into?</p> <p>S: Yeah just the just the session I just had, so that's from my understanding</p>	<ul style="list-style-type: none"> • just the session I just had, so that's from my understanding 	<ul style="list-style-type: none"> • Case as patient information
ABS-01	<p>R: And again this was for the case, for which you just came out of</p> <p>S: Sorry can you repeat the question? [chuckle]</p> <p>R: Mhmm sure. In reading the instructions for the questionnaire, how do you interpret the meaning of the word "case", "0" indicating not at all and "10" indicating completely</p> <p>S: And I give you a number?</p> <p>R: Yeah</p> <p>S: Oh ok.</p> <p>R: 0 to 10</p> <p>S: Uhm, [long pause] sorry</p> <p>R: That's alright</p> <p>S: Can you repeat the first part of the question one more time [chuckle]</p> <p>R: Sure, sure. In reading the instructions for the questionnaire,</p> <p>S: yeah</p> <p>R: Uhm how do you interpret the word "case" so in.. if you uhm 0 indicating you don't, you, not clear at all on the word case</p> <p>S: Oh ok</p> <p>R: And 10 indicating you under.. you understand completely the case.</p> <p>S: 10</p> <p>R: You understood completely the case?</p> <p>S: Yeah</p>	<p>Interviewer mis-interpreted the question – no clear directions of interviewee</p>	<p>Not gathered</p>
ABS-02	<p>S: Uh, 10</p> <p>R: Ok, you understand...</p> <p>S: The word "case"</p> <p>R: The word, what the case, what it referred to</p> <p>S: To</p> <p>R: In this particular uhm example</p> <p>S: Yes</p> <p>R: Ok</p>	<p>Interviewer mis-interpreted the question – no clear directions of interviewee</p>	<p>Not gathered</p>

Verbal Probe 2: What do the words “complex” and “complexity” mean to you when applied to simulation-based learning activities?			
Leppink-Paas Scale reference statements: #'s 1-2		Key phrases/Relevant Statements	Themes
PA-01	<p>S: Uhm, for me, the word complex and uhm complexity imply uhm, [short pause] the need for me to reach information that I may have only reviewed once. Information that uhm requires uhm possibly multiple uhm steps to get to versus baseline information uhm. For example, if I were talking about diagnosis of HTN, then reaching to what’s the worst case HTN could cause, like an organ damage versus just recognizing the diagnosis in front of you. R: Okay, good</p>	<ul style="list-style-type: none"> • information that I may have only reviewed once • Information that uhm requires uhm possibly multiple uhm steps to get to versus baseline information uhm. 	<ul style="list-style-type: none"> • Difficulty • Familiarity
PA-02	<p>S: Uhm I think complex or complexity would uhm have to be based on what I’ve already learned and uhm how much previous knowledge I have, I would say, uhm so something that was like very complex or something that was a little bit is more than what I’ve learned already in my program R: Okay</p>	<ul style="list-style-type: none"> • based on what I’ve already learned and uhm how much previous knowledge I have • something that was like very complex...is more than what I’ve learned already in my program 	<ul style="list-style-type: none"> • Difficulty • Familiarity
OT-01	<p>S: Different factors going into whatever this entity we are talking about. R: Okay</p>	<ul style="list-style-type: none"> • Different factors 	<ul style="list-style-type: none"> • Multiple elements

OT-02	<p>S: Uhh, complex, I just thought of like very heavy medical terms uhm anything medically related just that maybe a nurse or a doctor would be able to easily understand R: Alright</p>	<ul style="list-style-type: none"> • I just thought of like very heavy medical terms • maybe a nurse or a doctor would be able to easily understand 	<ul style="list-style-type: none"> • Difficulty • Familiarity
DPT-01	<p>S: Uhm, so I would say, the like complexity of the patient case would be if there was like multiple things going on with uhm the patient and I would kind of interpret both complex and complexity kind of meaning the same thing to me. I don't know that I would differentiate them as being different. R: Ok.</p>	<ul style="list-style-type: none"> • multiple things going on 	<ul style="list-style-type: none"> • Multiple elements

DPT-02	<p>S: [chuckles], in regards to this scale or just in general? R: Uhm, what do the words “complex” and “complexity” mean to you when applied to simulation-based learning activities? S: Activities.. R: Yeah S: Uhhh R: In this particular activity, specifically S: Sooo, I think that’s a little bit unclear so my interpretation of like complex or complexity in regards to like a SIM experience is more of like kinda like critical thinking uhm that you’re having to kinda navigate multiple components of you know like the patient case, such as like monitoring vitals and talking to the patient, talking to the daughter but I feel like, like when I had to answer those.. survey.. I didn’t really understand like what I meant. [laughs] R: Okay S: But, that’s how I answered it. R: That’s you’re, that’s, that’s you’re reference point, in your answer S: Yeah, yeah</p>	<ul style="list-style-type: none"> • kinda like critical thinking uhm that you’re having to kinda navigate multiple components of you know like the patient case, such as like monitoring vitals and talking to the patient, 	<ul style="list-style-type: none"> • Multiple elements
DPT-03	<p>S: Uhm I think in this case uhh the complexity was in reference to the situation in the simulation, like was the uhm the background information or the actual simulation complex R: Ok</p>	<ul style="list-style-type: none"> • complexity was in reference to the situation in the simulation • background information or the actual simulation complex[ity] 	<ul style="list-style-type: none"> • Difficulty • Multiple elements

DPM-01	<p>S: Uhm probably like learning something new like kind of using uh different aspects of your knowledge in your brain, coz it's definitely different like when you're in class, you're sitting there, absorbing information and you're doing this, you're thinking why am I asking these questions? Like uhm it's just a totally different way of thinking, so I think that that would be more complex and a different kind of learning</p> <p>R: Mhmm</p> <p>S: Yeah</p>	<ul style="list-style-type: none"> • learning something new like kind of using uh different aspects of your knowledge in your brain • absorbing information and you're doing this, you're thinking why am I asking these questions? • just a totally different way of thinking 	<ul style="list-style-type: none"> • Deep learning • Chunking
DPM-02	<p>S: Complex will be the difficulty of learning</p> <p>R: The difficulty of? I'm sorry</p> <p>S: The the</p> <p>R: The difficulty of the learning</p> <p>S: Yeah</p> <p>R: Yeah, ok</p> <p>S: And about the learning structure uhh instruction and the medical knowledge and terminology</p> <p>R: The medical knowledge and what else?</p> <p>S: And terminology</p> <p>R: Terminology. Uh huh, thank you.</p>	<ul style="list-style-type: none"> • difficulty of learning • instruction and the medical knowledge and terminology 	<ul style="list-style-type: none"> • Difficulty • Familiarity
ABS-01	<p>S: Uhm, both the difficulty in terms of understanding what's happening and being able to put everything together and know what to do in a scenario.</p> <p>R: Ok</p>	<ul style="list-style-type: none"> • difficulty in terms of understanding what's happening • being able to put everything together and know what to do 	<ul style="list-style-type: none"> • Difficulty • Familiarity • Multiple elements

ABS-02	S: Uhm difficult, multistep, uh having to use critical thinking and applying what we've been learning into real life practice R: Ok	<ul style="list-style-type: none"> • difficult, multistep, uh having to use critical thinking 	<ul style="list-style-type: none"> • Difficulty • Judgement
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Verbal Probe 3: What specifically were you thinking of or about when rating the statements in the questionnaire that used the terms “complexity” or “complex”?		
Leppink-Paas Scale reference statements: #'s 1-2	Key phrases/Relevant Statements	Themes
PA-01 R: What were.. so specifically, what were you thinking about? S: Uhm, [short pause] I think I was thinking of that, what I just explained, is uhm I didn't, I felt that the questions and the task, tasks asked of me, were very straight forward versus needing to determine uhm a plan of care, medication, and the dosing, uhm or what not to miss or various uhm potential diagnoses for this one reading. Uhm so I was thinking of it as this was more straight forward versus needing for me to create something out of the situation within the time given and information R: Okay	<ul style="list-style-type: none"> more straight forward versus needing for me to create something 	Difficulty Familiarity
PA-02 S: Uhm, I was thinking about the uhm I guess the medical situation and how difficult it would be uhm to come in and interpret it from uh the patient's I guess uhm symptoms or R: Okay S: Yeah	<ul style="list-style-type: none"> how difficult it would be uhm to come in and interpret 	Difficulty Familiarity

OT-01	<p>S: Can you repeat that one more time? R: Uh huh, what specifically were you thinking of or about when in the rating statements in that interview, in that survey in the questionnaire that used the terms “complexity” or “complex”? S: I think mostly it was terms that I did not know or would be too complex, so knowing that everything here was you know, I was able to understand, so it was average four/five R: Okay, uhm and so you you uhm interpreted the terms complexity or complex when you, when you rated that? S: Yes R: As terms that you didn’t know? S and R: Unfamiliar S: Unfamiliar, didn’t know, pretty much that was it</p>	<ul style="list-style-type: none"> terms that I did not know or would be too complex 	Familiarity
OT-02	<p>S: Uhm, say that one more time R: Uh huh, what specifically were you thinking of or about when rating the statements in the questionnaire that used the terms “complexity” or “complex”? S: Uhm I thought about the, like orientation before actually going into the simulation activity and what was presented during that orientation, the content. R: Anything else? S: Uhh no</p>	<ul style="list-style-type: none"> what was presented during that orientation, the content 	Difficulty Familiarity

DPT-01	<p>S: Mmmmm which..?</p> <p>R: So questions 1-4 used the word complex or complexity</p> <p>S: Yeah</p> <p>R: And so what were you thinking about, uhm when you were reading the statement that had those terms in it.</p> <p>S: Uhm, I was thinking of both the patient case as well as the scenario that I was kind of in when I was in the room. Uhm so kind of the combination of the two.</p> <p>R: And how would you differentiate the case from the scenario?</p> <p>S: Uhm, I think the case is what I was initially like had in my mind of going into like, oh this case doesn't seem too complex but then adding in the like uhh scenario in the room made it a little more complex because there's more things going on.</p> <p>R: Okay</p>	<ul style="list-style-type: none"> • I was thinking of both the patient case as well as the scenario that I was kind of in • adding in the like uhh scenario in the room made it a little more complex because there's more things going on 	Multiple elements
DPT-02	<p>S: Uhm, I was kind of trying to think about uhm just the, the experience overall. So in terms of like what we were given as far as like background information and then the interactive simulation, so kind of trying to bring in all of those things.. together to me, would be like more complex and less complex would be just having to have like uh face to face interaction with somebody or something like that</p> <p>R: Okay</p> <p>S: Does that make sense?</p> <p>R: Mhmm</p> <p>S: Okay</p> <p>R: Yeah, of course</p>	<ul style="list-style-type: none"> • in terms of like what we were given as far as like background information and then the interactive simulation, so kind of trying to bring in all of those things together 	Multiple elements

DPT-03	<p>S: I was thinking if the case was complicated</p> <p>R: Ok [short pause] and what would make it complicated?</p> <p>S: Uhm, [short pause] you.. you're referring to the actual simulation?</p> <p>R: Mhmm, yes</p> <p>S: Ok, uhm tsk, just the dynamic between daughter and mother, dynamic between patient and therapist, if the diagnosis or disease or whatever I was seeing on the monitor if it was adding complexity to like my overall decision making.</p>	<ul style="list-style-type: none"> just the dynamic between daughter and mother, dynamic between patient and therapist, if the diagnosis or disease or whatever I was seeing on the monitor if it was adding complexity to like my overall decision making 	Multiple elements
DPM-01	<p>S: Uhm [long pause] probably like similar to what I just said like thinking about something being more complicated than normal, something you would encounter, it's not something usually you would encounter. Like, its school or going to class.</p> <p>R: So, something different than you than you encounter in class?</p> <p>S: Yeah, completely different</p>	<ul style="list-style-type: none"> it's not something usually you would encounter 	Familiarity
DPM-02	<p>S: Will be complex interaction with the patient and also the difficulty of the case which means finding their medical history, their present illness</p>	<ul style="list-style-type: none"> complex interaction the difficulty of the case 	Multiple elements Difficulty
ABS-01	<p>S: [long pause] The difficulty of knowing what to do given a particular scenario or given a particular task, how difficult or easy it was for me to understand what to do</p>	<ul style="list-style-type: none"> difficult or easy it was for me to understand what to do 	Difficulty

<p>ABSN-02</p>	<p>S: What was I thinking about? R: Uh huh, what were you thinking about? [long pause] when you were rated those questions S: Just, [sighs] the, the the activity, simulation we just had to do and what I messed up on or like what's, what I could have done better, that's honestly what I was thinking about, uhm and how there was.. it wasn't just like cut and dry scenario, it took numerous steps, there was multiple moving parts and how things could have been shifted around R: Ok S: If that makes sense R: Yeah, yeah S: Ok</p>	<ul style="list-style-type: none"> • it wasn't just like cut and dry scenario, it took numerous steps, there was multiple moving parts and how things could have been shifted around 	<p>Multiple elements</p>
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Verbal Probe 4: In Q3 the phrase “complex term” is used. How would you define a “complex term”?			
Leppink-Paas Scale reference statement #3		Key phrases/Relevant Statements	Themes
PA-01	S: I mean for me a complex term is something I don't understand. Uhm, or a term that I cannot determine the meaning of when its being used in a sentence. R: Okay S: That, that's just me	a complex term is something I don't understand	don't understand
PA-02	S: Complex term would be a term that I don't understand or a term that uhm I haven't been taught before R: Okay	term that I don't understand	don't understand
OT-01	S: Again probably a term I do not understand [laughs] or haven't heard coz there's so many medical terms we hear, so at least we're familiar but I think it would be one that I just don't recognize at all R: Okay	I do not understand or haven't heard	don't understand
OT-02	S: For question 3? R: For question 3 S: How would I define a complex term? Uhm, I would define that as uhm just medical terms, uhm with, [chuckle] off-sounding, I don't know, how do you call that? Like syllables? strange letters paired up together. R: Okay S: Difficult to pronounce, uhm medical phrases R: Mhmm, okay	I would define that as uhm just medical terms	Medical Terminology
DPT-01	S: Uhm complex terms, I would say if you're talking about specific cardiac like arrhythmias or whatnot, like the specific names for them like uhmm like a PVC or like atrial fibrillation. I would say that those are more like complex terms uhm R: Because.. you're not familiar with them? Or..?	a healthcare practitioner would be familiar with it but it's not necessarily terms that like the average person would be familiar with	Medical Terminology

	<p>S: Uhh, just it's not, like a healthcare practitioner would be familiar with it but it it's not necessarily terms that like the average person would be familiar with. Uhm I'm not sure that it would be considered like complex terms may not be considered patient friendly language</p> <p>R: Ok</p>		
DPT-02	<p>S: Uhhhm [short pause] I would say probably something that's a little bit more like medical complex? Uhm, so, I said, I kind of rated it in the middle just because I wasn't like totally sure what it meant but that's kinda how I interpreted it and based on some of the stuff that we had to answer, or like have a plan for. As far as the background, I did have some medical terminology and things that we needed to know.</p> <p>R: Okay</p> <p>S: So, I think I was thinking more while answering this questionnaire that I actually was like in the SIM [chuckles]</p> <p>R: That's alright, but you, when you, when you you uhm, when you uhm say medical, you're referring to medical, the terminology?</p> <p>S: Yeah, like cardiac, dysrhythmia, a-fib, that kind of stuff</p> <p>R: Okay</p>	<p>I would say probably something that's a little bit more like medical Yeah, like cardiac, dysrhythmia, a-fib, that kind of stuff</p>	<p>Medical Terminology</p>
DPT-03	<p>S: Uhm when I was reading, when I was like preparing for the actual simulation. When I got like the background information, I was, that's what I was referring to, for terms.</p> <p>R: Ok</p> <p>S: For the terms in that background information complex</p>	<p>either I didn't understand what they were referring to or it made the case more complicated</p>	<p>don't understand Medical Terminology</p>

	<p>R: And what made them, so the terms were complex because</p> <p>S: Hmm, [long pause] uhhh either I, either I didn't understand what they were referring to or it made the case more complicated. So both situations.</p>		
DPM-01	<p>S: Uhm, I was thinking like vocabulary, like actual words, like uhm how Dr. Nair was talking to me through the simulation. Like I thought of it like, oh was it hard to understand? Or the actual instructions for the activity. When, I didn't feel like it was that, it wa.. it wa.. I felt like it was understandable</p> <p>R: Okay</p>	<p>thinking like vocabulary, like actual words</p> <p>was it hard to understand?</p>	<p>don't understand</p>
DPM-02	<p>S: Difficult</p> <p>R: Difficult in what way?</p> <p>S: Difficult, [short pause] take a long time to process</p> <p>R: Anything else?</p> <p>S: That's it</p> <p>R: That's it, okay</p>	<p>Difficult</p> <p>take a long time to process</p>	<p>don't understand</p>
ABSN-01	<p>S: [long pause] a word or set of words that are difficult to understand or [long pause] know what they mean</p> <p>R: Yeah</p> <p>[long pause]</p> <p>S: Ok</p>	<p>word or set of words that are difficult to understand</p>	<p>don't understand</p>
ABSN-02	<p>S: Kind of like before, uhm just difficult, multistep, uhm, I don't know the best way for me is like, lots of moving pieces, like a puzzle, that can be fit together in different ways</p>	<p>like a puzzle, that can be fit together in different ways</p>	<p>interacting elements</p>

Verbal Probe 5: In Q4 the phrase “high mental effort” is used. How do you define “high mental effort”?		
Leppink-Paas Scale reference statement #4	Key phrases/Relevant Statements	Themes
PA-01	S: I think in the same way similar to complexity, uhm, if I were to have been asked for example what may be causing her uhm a-fib or her palpitations, what may have been the cause. That would have required more mental effort because I am uhm not experienced uhh enough to come up with those things quickly uhm and so that would require more mental effort R: Okay	because I am uhm not experienced uhh enough to come up with those things quickly Inexperience Limited prior knowledge
PA-02	S: High mental effort, I would define it as uhm [short pause] uhm using using a lot of background, or a lot of my previous knowledge that I’ve learned to uhm I guess bring around and use in the, in the situation that I’m in right now R: Okay	using a lot of background, or a lot of my previous knowledge Use of prior knowledge Multiple components
OT-01	S: A lot of problem solving, a lot of trying to apply all these clinical skills that we’re trying to gain right now [short pause] uhm, then, its such a novel experience so I think that’s what really made it more high, requiring that high cognitive for me. And also the SBAR, that was first time ever trying [laughs] to use that, so I think that’s that all went into why it was a 7	trying to apply all these clinical skills that we’re trying to gain right now a novel experience first time ever trying Novel skill or activity
OT-02	S: High mental effort is my uh ability to strategize to interpret, to assess, uhm basically to make a decision about what I’m, what information I’m receiving and what information I’m giving out	uh ability to strategize to interpret, to assess Higher level thinking Multiple components

	R: Okay		
DPT-01	S: Uhhh I would say high mental effort, I would define it as requiring a lot of thought components in uhm when you're thinking about it the situation you're having to think of multiple things at once instead of just like one task. And uhm a bit more like multi-tasking. R: Ok	having to think of multiple things at once instead of just like one task.	Multiple components
DPT-02	S: Mmm, tsk, kind of, again kind of like trying to bring in like different aspects of like thinking so like more critical, having to base that on like my outward expression of concern, talking to the patient, talking to the daughter so like having to do like a little bit more higher-level thinking R: Okay	bring in like different aspects	Multiple components
DPT-03	S: Uhhh if high mental effort for me means that I have to string together [short pause] mo.. you know, more than a couple of thoughts to make sense of something. If I have to kind of, logic through a situation rather than just kinda knowing the answer intuitively.	I have to string together you know, more than a couple of thoughts to make sense of something	Multiple components
DPM-01	R: In Q4 the phrase "high mental effort" is used. S: [chuckles] R: How do you define "high mental effort"? S: Uhm, probably using like everything you have learned and using it like for the activity so uhm kind of like integrating all those different kinds of thinking. I felt like it took a lot of mental effort coz you're trying to remember a lot of different things at the same time.	integrating all those different kinds of thinking you're trying to remember a lot of different things at the same time.	Multiple components

DPM-02	S: Uhm, have to constantly engage between the simulation situation and correlate to the real life R: Between the simulation uhm situation and and S: And try to correlate to R: Correlate uh huh S: To real life	constantly engage between the simulation situation and correlate to the real life	Using prior knowledge Multiple components
ABSN-01	S: Amount of thinking and cognitive input that I have to use to understand, something [quietly]	cognitive input that I have to use to understand	Thinking for understanding
ABSN-02	S: Uh, just takes a lot of cognitive effort. Uh, there is a term we learned in class, I can't remember. Mentation or something like that? [chuckles]. Just thinking uh, using like just using your brain and thinking about all yeah, that's all I got really R: that's good S: ok	just using your brain and thinking	Thinking

Verbal Probe 6: How do you determine if explanations and instructions are “unclear”?			
Leppink-Paas Scale reference statement # 5		Key phrases/Relevant Statements	Themes
PA-01	<p>S: Uhm, for me, uhm, so I’m a DRC student, so I feel that sometimes in general I have to read the questions at least two times. Uhm I feel that if a question, if I can’t, if I can have two separate meanings to one question. If I’m, if I’m not certain what their intention is, it’s not clear to me and I could, justify one and then justify another. Then that to me is unclear</p> <p>R: Okay, that’s good</p> <p>S: [chuckle]</p>	<p>if I’m not certain what their intention is, it’s not clear to me and I could, justify one and then justify another</p>	Double meaning
PA-02	<p>S: Uhm, I would determine that they are, they would be unclear if I wasn’t given any at all, probably, is that</p> <p>R: So you would uhm, if, if you had some uhm instructions, how would you determine that they were unclear?</p> <p>S: Uhm I think I would determine if they were unclear by if I didn’t have any additional questions</p> <p>R: Mhmm</p> <p>S: Uhm</p> <p>R: So, unclear is you don’t have any additional questions, you have</p> <p>S: Right</p> <p>R: You understood the</p> <p>S and R: [simultaneously] direction from the explanation</p> <p>S: Yes</p> <p>R: Initially</p> <p>S: Mhmm</p> <p>R: Okay</p>	<p>think I would determine if they were unclear by if I didn’t have any additional questions</p>	No questions Understanding
OT-01	<p>S: How I determine?</p> <p>R: Mhmm</p> <p>S: I don’t understand them, everything that was explained I was able to understand clearly</p> <p>R: But in general, you determine explanations and instructions are unclear if you don’t understand them?</p> <p>S: If I don’t understand them</p> <p>R: Okay</p>	<p>I don’t understand them</p>	Understanding

OT-02	<p>S: How do I determine if they're unclear? R: Yeah, if any explanation/instructions, how do you determine that those are unclear to you S: If I really don't know what uhh is being said, uhm, I try to ask a question for clarification. If it, if it's not making sense, if I wouldn't be able to reproduce, if like, if I were to stop and and say okay, this is what I understand so far, if I don't have something I could say after that, then I know that I'm not really understanding the information that was just given to me R: Okay</p>	<p>if it's not making sense I try to ask a question for clarification.</p>	Understanding
DPT-01	<p>S: [short pause] To me unclear would be like if I had no, if I didn't understand what I was being asked, like number 8. [laughs] R: Ok</p>	<p>if I didn't understand</p>	Understanding
DPT-02	<p>S: To me, if I went into the simulation not knowing what was asked of me, that would make me think that the explanation or instructions weren't clear. R: Okay S: That's how I interpreted that</p>	<p>not knowing what was asked of me</p>	Understanding
DPT-03	<p>S: Sorry say that again R: Uh huh, how do you determine if explanations and instructions are "unclear"? S: How do I determine. R: Uh huh S: If I have to read them more than once or twice or if I just don't understand the sentence structure.. immediately</p>	<p>If I have to read them more than once or twice</p>	Understanding
DPM-01	<p>S: Uhm, can you say that again? R: How do you determine if explanations and instructions are "unclear"? S: Uhm, I guess if they're like vague. Or kind of like, if you're just thrown in, like okay just go. So I like that she brought us into the room, and got to see the manikin coz at first we were all like kinda nervous</p>	<p>if they're like vague there is not really any instruction</p>	Minimal/vague

	uhm so I guess if it's just like vague or there is not really any instruction on like what to do		
DPM-02	<p>[long pause] S: [mumbles] explanations and instructions are "unclear" [long pause] S: I think it's pretty clear R: And how do you determine that, how do you determine if your given instructions that or an explanation that its clear or not S: So that will be in the briefing room, talk about what we are going to do and what will going to happen and order structure was given prior we enter the simulation room. [short pause] So maybe I need to R: You don't need to. Yeah, that's okay, yeah that's fine S: Ok R: Uhm, we just want to understand how you interpret that and uhm and how you determine if those instructions were clear. So how did you determine if those instructions that you received were clear S: We're clear is I know what am I going to do, and going to interact or encounter before I enter the room R: Ok, perfect</p>	Clear is I know what am I going to do....before I enter the room	Understanding
ABSN-01	<p>S: Sorry, how do I? R: How do you determine? S: Determine R: Explanation or instructions are unclear S: If I understand what I'm supposed to do, uhm, or whether or not I, yeah, whether or not I know, what to do given what they were just told, [whispers] "what they told you" R: So if you're not given enough S: If it was, sorry, yeah so if it was unclear if I'm confu., if it was unclear I would be confused if it was clear then I would know exactly what to do</p>	I understand what I'm supposed to do	Understanding
ABSN-02	S: How lost I feel going in to something, uhm, like knowing	How lost I feel going in to something	Understanding

<p>what to expect, I guess. It's just hard though, coz we don't have, I've been here for seven weeks so I don't have a lot of experience behind me to really, I mean I guess you compare it to previous and past experiences and I don't have a lot to compare it to R: But in general, unclear S: Oh unclear in general, just not giving enough instructions and not knowing R: Ok</p>		
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Verbal Probe 7: What makes language unclear for you?			
Leppink-Paas Scale reference statement #6		Key phrases/Relevant Statements	Themes
PA-01	S: uhm I think partially it's that English is my second, second language and so a lot of uhm common terms, I didn't grow up with. So sometimes I feel that that's the language barrier. Uhm and la.. and again just lack of experience and exposure to different uhm specialties if I have never seen it or heard it before, it's go.. it's gonna take time and repetition, for me, for it to be familiar R: Good	English is my second, language and so a lot of uhm common terms I didn't grow up with	ESL Understanding
PA-02	S: Uhm, [short pause] I think that [short pause] language being unclear to me would be uhm [long pause] hmm, sorry gotta think about that one for a second. R: No that's fine, take your time S: Okay, [long pause] language being unclear to me would be using phrases or any words that I don't know or I don't understand R: Okay	phrases or any words that I don't know or I don't understand	Understanding
OT-01	S: Language.. language [short pause] hmm. I don't, also if I don't understand the language in terms of vocabulary, the way it's being presented [short pause] also the order of it too, matters for me R: Okay, the order of, what do you mean when? S: The information being presented R: Okay	the way it's being presented....also the order of it too	Presentation
OT-02	S: What makes language unclear? Uhm if I don't know the definitions of terms or if I haven't heard a certain phrase uhm that's used. R: Okay S: I think also if someone is speaking and I just can't. Maybe it's my fault or	don't know the definitions of terms or they're mumbling	Presentation

	they're mumbling, then I can't tell what they are saying.		
DPT-01	S: Uhm, I think if words are being used that you don't understand, then it's kind of like you're missing that link of like what is actually being asked because you don't know what the word really means. R: Ok S: I think, yeah [laughs]	if words are being used that you don't understand	Understanding
DPT-02	S: [laughs] Uhm, if they use, if terminology is used that I'm not familiar with, uhm, or maybe if the language used doesn't necessarily fit the, established like context that we are gonna have to use it in. R: Mhmm S: I guess, maybe? R: That's fine.	if the language used doesn't necessarily fit the, established like context	Presentation
DPT-03	S: Uhm, I guess it's just a feeling, [laughs] I don't know. Uhh maybe something that's wordier, wordier than, than it, needs to be, if uhm terms are like unnecessary terms are used to make the sentence more complex. It makes it more difficult to read or hear R: Ok	maybe something that's wordier, wordier than, than it, needs to be	Presentation
DPM-01	S: Uhm [long pause] let me think, probably [sighs and long pause] probably not, I don't know, I don't know. That's kind of like uhm maybe just lack of like actual direction or instruction or like if there's not a goal that's clearly stated. I'd, I like to know what, what am I trying to accomplish, you know? And like certain steps I can take to get there, but as long as I know what I need to accomplish, I can just do it so I think just defining a goal for whatever activity it is. R: Okay S: Yeah	there's not a goal that's clearly stated.	

DPM-02	S: Too much detail, in have to comprehend in a short amount of time. So that could be difficult. So that to say we uh in the briefing for five minutes but we have to do ten minutes interaction in the room so that five minutes in briefing room may not be sufficient to cover whole ten minutes, of what we are going to do. R: Okay	much detail, in have to comprehend in a short amount of time	Presentation
ABSN-01	S: The particular order or wording of something R: Mhmm, anything else [Long pause] R: Anything else? S: Uhm, particular words that may or may not be used. Uhm, if there is vocabulary that I don't know or if there is a synonym that is used that is not exactly what they mean R: Ok S: Yeah, so vocabulary	The particular order or wording of something is vocabulary that I don't know	Presentation Understanding
ABSN-02	S: Uh the word being u.. like words, unknown words uhm that's all, yeah, words you don't know, or, that's about it R: Ok	words, unknown words	Understanding

Verbal Probe 8: How do you determine if explanations and instructions are “ineffective” in terms of contributing to your learning?			
Leppink-Paas Scale reference statement #7		Key phrases/Relevant Statements	Themes
PA-01	<p>S: Uhm, I feel that if there is absolutely no connection, there’s no uhm recollection of it, uhm when I’ve learned it to pass an exam. However, I have no image in my head feeling or ability to recall a memo..memory like attainable whether its touch, or visually, I feel that its ineffective. [chuckle]</p>	<p>if there is absolutely no connection I have no image in my head feeling or ability to recall a memory</p>	No context - link
PA-02	<p>S: I would say that explanations and instructions are ineffective if I go into a situation and I felt like I was just being thrown in there with, with no information, I know that [chuckle] that’s kind of uhm, [short pause] let’s see. How can I explain that a little better? Uhm [long pause] R: Do you want me to read it to you again? S: Yeah, one more time R: Yeah sure, how do you determine if explanations and instructions are “ineffective” in terms of contributing to your learning? S: Uhm, oh okay, so if explanations and instructions aren’t effective in contributing to my learning, I think it would be uhm more about what I’m supposed to get out of the the simulation maybe? Uhm and uhm [tsk] kind of [long pause] hmm, I don’t know, this is this is hard [nervous laugh] R: So how would the uhm, take your time, we have</p>	<p>Uhm I would say if they don’t have a little bit of background</p>	No context - link

	<p>plenty of time. So how do you determine if, if uhm the instructions are not helping you? How, what, what, would be a part of the instructions that are ineffective, how would they not help you? uhm if somebody gives you an explanation or gives you directions and they're ineffective so what don't they have that would help you, uhm understand or, or you know, contribute to your learning?</p> <p>S: Uhm I would say if they don't have a little bit of background uhm and what I would be doing in the simulation, so does that, does that make sense?</p> <p>R: Yeah yeah,</p>		
OT-01	<p>S: Ineffective, hmmm [short pause] maybe if I'm not gaining what is intended.</p> <p>R: Okay</p>	I'm not gaining what is intended	Understanding
OT-02	<p>S: Uhm if I don't see how the information is relevant or uhh if its lengthy and there no clear objective in what's being said and then also I think, uhm [short pause] the quality of the words. If they're a little more simple, their easier to understand</p> <p>R: Okay</p>	I don't see how the information is relevant no clear objective easier to understand	Understanding No context - link
DPT-01	<p>S: Ooh, can you read that again?</p> <p>R: Uh huh, how do you determine if explanations and instructions are "ineffective" in terms of contributing to your learning?</p> <p>S: Hmm, I would say.. uh oooh. Yeah I would, I would say, that I would consider them ineffective if I can't, if I can't uhhh like think about what is</p>	like being able to put things in perspective of my own like thought process didn't understand what was being asked of me	Understanding No context - link

	<p>being asked in like my own, like being able to put things in perspective of my own like thought process of, of oh man that's a, that's a hard question.</p> <p>[both chuckle]</p> <p>R: So if you were given an explanation or some instructions, what would make it ineffective for you?</p> <p>S: Yeah, I think if I just didn't understand what was being asked of me then it would be, it would be ineffective question and then I wouldn't be able to learn from it coz I wouldn't really understand what was being asked of me.</p>		
DPT-02	<p>S: uhm, if they are ineffective, I would think that they don't kind of prime me for what's expected of my learning. So, uhm, or if they're kind of like vague instructions, I think that that would like be a little more ineffective for learning</p> <p>R: Okay</p>	<p>don't kind of prime me for what's expected of my learning kind of like vague</p>	<p>Understanding No context - link</p>
DPT-03	<p>S: Uhm, if something is ineffective in contributing to my learning. [short pause] Again if it's, if uhm, if the words being read or the words being heard are difficult to follow because of structure or terminology is too is like unnecessarily difficult. You could use much simpler language or more direct language to get the same point across.</p> <p>R: Ok</p>	<p>difficult to follow because of structure or terminology is too is like unnecessarily difficult</p>	<p>Presentation – simpler language</p>
DPM-01	<p>S: Probably if I feel like the instructor or like whoever is in charge of it, doesn't... know, like it is unsure of the instructions, or their</p>	<p>Like if I feel like I.. the instructor is in like command and knows what were suppose to be doing and what the goal is, I feel a lot more reassured, like I can do it.</p>	<p>Presentation – instructor confidence</p>

	<p>instructions. So I feel uncertain about it. [short pause] Like if I feel like I.. the instructor is in like command and knows what were suppose to be doing and what the goal is, I feel a lot more reassured, like I can do it.</p> <p>R: Ok, so if the instructor's competent?</p> <p>S: Yeah</p>		
DPM-02	<p>S: Ineffective</p> <p>R: Yeah, how do you determine if explanation...</p> <p>S: Ineffective will be what we go over in the briefing room doesn't match what we actually learn in the simulation room. So that would be ineffective.</p> <p>R: So the pre-briefing doesn't match the</p> <p>S: Yeah</p> <p>R: The scenar..</p>	<p>Ineffective will be what we go over in the briefing room doesn't match what we actually learn in the simulation room</p>	<p>Presentation – incongruency</p>
ABSN-01	<p>S: If I did something based on what I understand, based on the explanation or instruction I was given and I did it wrong. Or I wasn't successful at doing it, given what I was, based on what I was given, then I would deem it ineffective</p> <p>R: Mhmm, ok last question</p>	<p>I wasn't successful at doing it, given what I was, based on what I was given, then I would deem it ineffective</p>	<p>Success = effective</p>
ABSN-02	<p>S: [long pause] Uh, that's a good one. Uhm, just. I mean tests, I guess and like how you do on a test based on how you felt how much like, if I put a lot of effort into a test and I do really bad then maybe I wasn't taught it well enough or I mean it could also be like a user errors and I didn't study well enough. Uhm, just feeling lost, [whispers]. I don't know. You need more? Do you need more?</p>	<p>if I put a lot of effort into a test and I do really bad then maybe I wasn't taught it well enough</p>	<p>Success = effective</p>

	<p>R: No, no, no, if but yeah, yeah no, so if if explanations and instructions aren't effective you feel lost? S: Like I feel lost, I'll be unclear on a subject that maybe I can like, if I learn it myself when I didn't learn from being taught it, then maybe that's why? [Whispers] I don't know R: Ok, that's fine</p>		
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Verbal Probe 9: In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? This includes the brief, actual activity as well as the debrief.			
Leppink-Paas Scale reference statement #4		Key phrases/Relevant Statements	Themes
PA-01	<p>S: Okay, so during the briefing, uhm [short pause] I fe.. I was straining to remember what ISBAR meant. Uhm I feel like we aren't trained to look at patient cases in this manner and uhm some people have more experience with this so they're more familiar, I've only ever heard it once during orientation and that was a long time ago now. [chuckle] So I was very uhm, even though and so defining and put categorizing those terms uhm was challenging. Uhh also during the simulation, hearing the noise of the monitor and then trying to continue to listen to the faint voice uhm while trying to discern what the reading from the EKG was, was challenging.</p> <p>R: Okay, and anything during the debrief?</p> <p>S: Uhh, feeling uhm I didn't come up with a plan. I didn't uhm [tsk tsk]. I didn't come up with a plan so that was, I couldn't uh formulate it into a solid, this is what we're going to do</p> <p>R: Okay, do you have any other questions or do you have anything that you want, you want to ask me?</p> <p>S: No</p> <p>R: So we're finished.</p>	<p>I was straining to remember what ISBAR meant</p> <p>during the simulation, hearing the noise of the monitor and then trying to continue to listen to the faint voice uhm while trying to discern what the reading from the EKG was, was challenging.</p>	<p>Tenuous understanding of past knowledge</p> <p>Attention to multiple elements at the same time</p>
PA-02	<p>R: So this is the last question, in referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? So this includes the brief, and the actual simulation and the debrief.</p> <p>S: Okay uhm, definitely high</p>	<p>definitely high mental effort when I was reading the page that I was given, the green page uhm with my uhm situation and kinda the past medical history of the patient</p> <p>I think throughout the simulation, just kinda uhm of digging deep into my history questions and things like that was uhm high</p>	<p>Processing multiple elements at the same time</p> <p>Needing to access tenuous past knowledge</p>

	<p>mental effort when I was reading the page that I was given, the green page uhm with my uhm situation and kinda the past medical history of the patient. Kind of took that all into context and uhm was trying to figure out what I would be doing in the simulation and uhm what I would need to do intervention wise or how I was going to complete my task. Uhm and then also when I was in the simulation uhm [tsk] I think throughout the simulation, just kinda uhm of digging deep into my history questions and things like that was uhm high mental effort</p> <p>R: High mental effort? mhmm, and what about the debrief? Was there anything about the debrief that had high mental effort?</p> <p>S: No</p> <p>R: Nope,</p> <p>S: The debrief, like talking to the provider in the room or after?</p> <p>R: After the whole scenario was over, and I know it was a very short debrief</p> <p>S: Uhm</p> <p>R: Was there any?</p> <p>S: I don't, no, there wasn't</p> <p>R: Okay, great! That's it.</p>	<p>mental effort</p>	
OT-01	<p>S: Hmm. Well the brief, once I saw SBAR, uhm, I had to ask when she came back in what each letter represented, so kind of going through the flow of what's expected for the SBAR handoff. And then during, I was trying to cover them all in my head so I was trying keep up with this thing that I just, we learned it before but I've never actually hadn't tried to implement it. So trying to incorporate that into the entire experience and then after..</p> <p>R: And then during the SIM</p>	<p>I had to ask when she came back in what each letter represented I was trying keep up with this thing that I just, we learned it before but I've never actually hadn't tried to implement it.</p>	<p>Needing to access tenuous past knowledge</p> <p>Processing multiple elements at the same time</p>

	<p>experience? The actual activity?</p> <p>S: Mhmm, uhm, it was yeah, trying, there was a lot of thoughts trying to organize what the goal was and trying to figure out from the patient, but also trying to get all information from that ISBAR, uhm, and then, also it was kind of hard to hear so I was, it was, I want to be like professional, but also my ear is right up to the simulated patient</p> <p>R: Manikin?</p> <p>S: Uhhh yeah, but, what was the question overall? I think I'm just rambling</p> <p>R: right, right, no, in referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? So you explained your high mental effort during the brief, was understanding the SBAR</p> <p>S: Yes</p> <p>R: And then during the SIM was trying to...</p> <p>S and R simultaneously: Gather as much information</p> <p>S: As I can</p> <p>R: For, towards the goal</p> <p>S: Yeah, especially towards the end, I think that was the highest, or the highest was trying to give that information back towards the nurse or</p> <p>R: And in an SBAR format, is that what you're talking about</p> <p>S: Yes, yes</p> <p>R: And then the debrief?</p> <p>S: The debrief?</p> <p>R: I know it was very short, but is there, was there any?</p> <p>S: No</p> <p>R: No</p> <p>S: The feedback was helpful, but didn't require any high level of functioning</p>		
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	<p>R: Okay, good, do you have any other comments, questions?</p> <p>S: No, oh that was it?</p> <p>R: Yeah that was it.</p>		
OT-02	<p>R: Last question, in referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? And this includes the brief, the actual SIM and the debrief or feedback.</p> <p>S: Uhm I would say, so a time when, a moment when I felt that I needed to use complex..</p> <p>R: High mental effort</p> <p>S: High mental..</p> <p>R: Uhm, during the brief, then during the simulation and feedback</p> <p>S: Uhm, I would say it only happened uhm at the end, during the debrief. When I was explaining the uhh [short pause] I think it was the assessment or the recommendation, I can't remember. Only because uhm, the I think it was the PA, physician assistant she when she came in, she asked for uhm the heart rate readings and I had written so many down that I just, well I could list them all out but then I understood that I could summarize like that at this point this was the highest and at this point this was the lowest. uhm and just give like a general overview of it, rather than one by one, listing them one by one</p> <p>R: Okay</p> <p>S: Mhmm, so I was I I I immediately said well that's too many to say right now so I just didn't try [chuckle]</p> <p>R: Uh huh, and then during the brief, did you have any uhm, use used high mental effort? During the brief?</p>	<p>I had written so many down that I just, well I could list them all out but then I understood that I could summarize</p> <p>ok I mean we're not told what the scenario is gonna be exactly but we are told this is what the outcome needs to be and we're so fixated on getting that outcome that we forget a bunch of other things, one of which is flexibility</p>	<p>Thinking in the moment</p> <p>Realizing a need for flexibility</p>

	<p>S: No R: And the simulation itself? S: No R: Okay S: I thought those were okay, I I I mean nothing uhm extreme I would say, I felt pretty comfortable with that experience, those experiences R: Okay, do you have any more questions Nayela? Or anything to add? Or any other comments before we end this? S: No, I love simulation lab [chuckle] R: Good S: I mean as stressful as they can be, I think that it's very helpful to prepare and uh I was sharing this uhm earlier that we have to be flexible and I think that that's one thing that a lot of students forget when we're here because yes we're here in school for a certain purpose and the profession that were trying to get into, so I think when were given this assignment, ok I mean we're not told what the scenario is gonna be exactly but we are told this is what the outcome needs to be and we're so fixated on getting that outcome that we forget a bunch of other things, one of which is flexibility, second like just being yourself and you know, you're calling was to be in this profession, you're calling, you know, use that right now that you're in the room with the patient. Uhm but yeah I think it's good to feel I I like the stress of it, uhm I try not to let it hinder everything else that I know uhm so I appreciate the experience. R: Great!</p>		
DPT-01	R: In referring to the simulation activity that you	energy in the room kinda went up and the patient started reacting	Having to consider multiple changing components

	<p>just completed, can you tell me about any time that you experienced high mental effort?</p> <p>S: [chuckles]</p> <p>R: This includes the brief, the scenario and the debriefing.</p> <p>S: Ummm, I would say high mental effort would be when the daughter came in the room and she was very uhm concerned about her mom and the energy in the room kinda went up and the patient started reacting and had you know increase in heart rate and some arrhythmias in her ECG and uhm tsk yeah there was just kinda a lot going on. So that was [short pause] definitely more effort required mentally [chuckle]</p> <p>R: And anytime during the brief or the debrief?</p> <p>S: uhhmm, I would say just thinking about some, is, this is considered the debrief?</p> <p>R: No the debrief, you might have had a very brief debrief uhm with with Dr. Grieve after the scenario, did, yeah,</p> <p>S: Ummm</p> <p>R: You may not had the debrief</p> <p>S: I don't think we've had a debrief, yet.</p> <p>R: That's fine, so the pre-brief, the the part, or the brief, that, before the information, before you went into the scenario</p> <p>S: No, I felt that that was pretty clear</p> <p>R: Okay, so, and yeah, she sometimes has time to do a debrief or not, so</p> <p>S: Oh, yeah, I think we might do it after we're all done [chuckles]</p> <p>R: Okay, do you have any questions?</p> <p>S: No.</p>	<p>and had you know increase in heart rate and some arrhythmias in her ECG and uhm tsk yeah there was just kinda a lot going on. So that was [short pause] definitely more effort required mentally</p>	
DPT-02	R: In referring to the simulation activity that you	trying to think of how to assess the stability of the patient for out	Having to consider multiple elements/components

	<p>just completed, can you tell me about any time that you experienced high mental effort? And the experience includes the brief, actual activity and the debrief, if you've had a debrief.</p> <p>S: Uhm, so I would say when we were talking about the case, the patient case, uhm and in trying to think of how to assess the stability of the patient for out of bed activities. That kind of would be an example and also trying to interpret what was actually happening on the monitor, in the moment and kinda trying to assess uhm that situation.</p> <p>R: And anything about the uhm the brief, the pre-brief, before you went into the room?</p> <p>S: That's kinda when we did our little like assessment, planning</p> <p>R: Okay</p> <p>S: So that was kinda, the assessing the stability, of the patient before hand, like things we would look for in order to deem them stable or unstable</p> <p>R: Uh huh, okay, any questions? Do you have any things to add or?</p> <p>S: Ummm, I don't think so.. [hesitantly]. Yeah</p> <p>R: Okay</p> <p>S: Yeah, I think I'm good.</p>	<p>of bed activities. That kind of would be an example and also trying to interpret what was actually happening on the monitor, in the moment and kinda trying to assess uhm that situation.</p>	
DPT-03	<p>R: In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? This includes the brief and the actual activity.</p> <p>S: Uhm, I feel like this has cause more mental, higher mental effort than the actual simulation [both laugh]</p> <p>R: Fair enough</p> <p>S: Uhm, I think when I was</p>	<p>I was trying to answer the mother's question, is she having a heart attack? And I was [short pause] I, I knew the answer but I was like I think I was nervous to give her false information</p>	<p>Uncertainty</p>

	<p>trying to answer the mother's question, is she having a heart attack? And I was [short pause] I, I knew the answer but I was like I think I was nervous to give her false information</p> <p>R: Mhmm</p> <p>S: Yeah</p> <p>R: And anything about the brief? Was there any high mental effort</p> <p>S: Uhhh, the brief before?</p> <p>Uhm, no, I don't think there was high mental effort at that part</p> <p>R: Ok, alright, any questions?</p> <p>S: No</p> <p>R: Additional thoughts?</p> <p>S: No</p> <p>R: Ok</p>		
DPM-01	<p>R: In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort?</p> <p>S: The whole time [chuckles]</p> <p>R: This includes the brief, and actual activity as well as the debrief. And you haven't actually gone through your debrief.</p> <p>S: Right</p> <p>R: But uhm the the preparation for it and the actual activity uhm can you let me know what, where you experienced high mental effort</p> <p>S: Uhm I would say like in the prep for it, like making an outline for myself. That was the hardest part, once I had that laid out, I had it organized in my brain, so I could go and ask what I needed to ask. But I think also during like trying to stay focused on what you're doing and not getting lost in just asking meaningless questions. And making the patient feel comfortable, like they're being heard and like</p>	<p>Uhm I would say like in the prep for it, like making an outline for myself. That was the hardest part, once I had that laid out, I had it organized in my brain, so I could go</p> <p>like trying to stay focused on what you're doing and not getting lost in just asking meaningless questions.</p>	<p>Considering the whole and breaking it into pieces</p> <p>Maintaining concentration on the task during the sim.</p>

	<p>being sensitive about their pain. Coz it's easier to do that when it's a real person but it's like trying to remember okay this is like this is a real person. So [chuckles]</p> <p>R: Right, right</p> <p>S: So yeah, I think that,</p> <p>R: Keep that, reality</p> <p>S: Yeah coz you're learning while you're doing it so its like you don't want to be so focused on everything that you need to get down and not remember that this is a real person. So, that that's really hard [laughs]</p> <p>R: But it's it's uh it's part of the learning</p> <p>S: yes, yeah</p> <p>R: Okay so we're finished here, do you have any other questions?</p> <p>S: No</p>		
DPM-02	<p>R: In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? This includes the brief, actual activity and the debrief, but you actually haven't had your debrief yet so uhm any activity, the brief, or the simulation activity, uhm that you experienced high mental effort</p> <p>S: Probably the activity.</p> <p>R: The activity?</p> <p>S: Yeah</p> <p>R: And what was that in the activity that you you made you experience high mental effort?</p> <p>S: So the patient kind of just cry and kind of lose control, uh wasn't really prepared for that but that's what we're here for.</p> <p>R: Ok, do you have any other questions or comments?</p> <p>S: No</p> <p>R: Concerns? Nothing?</p>	the patient kind of just cry and kind of lose control, uh wasn't really prepared for that	Dealing with the unexpected

<p>ABSN-01</p>	<p>R: With the feedback S: Sorry, so particular times? R: So yeah S: Right, so examples? R: So can you tell me about uhm anytime you experienced high mental effort during this simulation experience that you just finished? S: When I took the glucose levels looking at the M..at MAR, uhm, I was given exactly 50, but the order was less than 50, but there was nothing for, in, above 50, I was, I had to think about what I was supposed to do. Uhm, when there was no instruction and just in the very beginning, orienting myself to where, what, where I should start R: Ok, [long pause] anything else? That's it.</p>	<p>Uhm, when there was no instruction and just in the very beginning, orienting myself to where, what, where I should start</p>	<p>Dealing with the unexpcted with no direction</p>
<p>ABSN-02</p>	<p>R: In referring to the simulation activity that you just completed, can you tell me about any time that you experienced high mental effort? This includes the brief, the actual activity just for this particular experience that you just came out of. So, give me an example or uhm or about uhm where you felt high mental effort. S: Tsss. The whole time, uhm no just prioritizing what needed to happen. Like I knew what my patient was here for. I knew you know past medical history, I had a brief overview of what was going on currently and we were just told to do an assessment which made it kind of like, I knew there was numerous things I had to do, but knowing which to do first and like getting a result from one you know portion that I did, makes you go, ok now I need to take another step but should I, you know,</p>	<p>The whole time, uhm no just prioritizing what needed to happen</p> <p>we were just told to do an assessment which made it kind of like, I knew there was numerous things I had to do, but knowing which to do first [was unclær]</p>	<p>Lack of direction, prioritization,</p>

	<p>where to put that in the list of things to do, kind of. R: Good, anything else that you want to add? S: Uhhh, nope R: Ok S: Nope, I don't think so R: Ok</p>		
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Appendix 10: I- SBAR Verbal Communication Measure

Case: Reliability Study/SG dissertation project

Type of Simulation: manikin

Objective of I-SBAR: Assess patient's stability for out of bed activity

Setting/Background: Patient on regular medical floor, dx of "dysrhythmia" and high HR, patient not OOB since admission the evening prior.

Category	Response									
I – Introduction	Name		0.5		Title				0.5	
S – Situation	Assess for stability and or ability with OOB activity (or some statement regarding why they are in the room)									1
B – Background	Admitted with dx of cardiac dysrhythmia, Not OOB since admit, or other appropriate statement regarding background									1
A – Assessment	HR*		O ₂ sat*		BP*		RR*		ECG** rhythm	A&O***
	0.5	1	0.5	1	0.5	1	0.5	1	0.5	0.5
R – Response/Recommend	Stable? Y/N		1		Rationale or Recommendation				1	
Total score: / 10										

Scoring Instructions:

- Place a mark in the shaded boxes if included in the verbal **I-SBAR** response
- Report total score out of a maximum possible of 10 points
- Assessment:
 - * If the recording includes mention of HR, O₂ sat, BP and RR without specific values, score as 0.5 point for each variable mentioned. If values are included score 1 point.
 - ** Appropriate answers for ECG rhythm include "tachy", "tachycardia" or "a-fib". If "racing heart" or "heart racing" is mentioned, score 0.5 under HR unless a value is provided which would then be a score of 1.
 - *** For A&O accept any indication for patient state such as anxious, stressed etc. for 0.5 points

Abbreviations:

- OOB – out of bed
- dx – diagnosed
- HR – heart rate
- O₂ sat – oxygen saturation
- BP – blood pressure
- RR – respiratory rate
- ECG – electrocardiogram
- A&O – alert and oriented

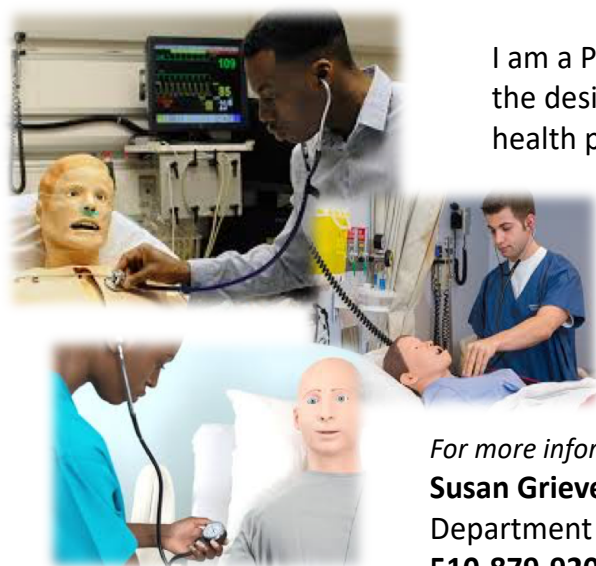
Appendix 11: Criteria for Participation - Inter-rater Reliability I-SBAR Scoring

Name	≥ 2 years of full time work experience on health care teams prior to transitioning to academic/clinical teaching	Team STEPPS Master Trainer or Foundations course training	Availability to assist with data collection during Phase 2 of this project - Summer term 2018

Indicate 'yes' or 'no' in each box for each participant

Simulation in Health Care Education Study

Interested in helping educators understand more about designing quality simulation experiences?



I am a PT Faculty at Samuel Merritt University hoping to understand how the design of a simulation experience affects the cognitive load experience of health professional students early in their education.

Who can help?

- Students in the DPT, MOT, OTD, PA, DPM and ELMNS programs who have finished basic science course work and have had Team STEPPS training through SMU.
- If eligible you will be asked to participating in 1 one hour session which includes a short simulation activity.

For more information, contact

Susan Grieve, PT, DPT, MS, OCS, Assistant Professor

Department of Physical Therapy, Samuel Merritt University

510-879-9200 x 7384

Sgrieve@samuelmerritt.edu



Appendix 14: Simulation Study Randomization Plan

2/28/2018

A Randomization Plan
from
<http://www.randomization.com>

1. Std-Brief _____
2. Std-Brief _____
3. EP-Brief _____
4. EP-Brief _____
5. Std-Brief _____
6. EP-Brief _____
7. EP-Brief _____
8. Std-Brief _____
9. EP-Brief _____
10. Std-Brief _____
11. EP-Brief _____
12. Std-Brief _____
13. Std-Brief _____
14. Std-Brief _____
15. EP-Brief _____
16. EP-Brief _____
17. Std-Brief _____
18. EP-Brief _____
19. EP-Brief _____
20. Std-Brief _____
21. EP-Brief _____
22. EP-Brief _____
23. Std-Brief _____
24. Std-Brief _____
25. EP-Brief _____
26. Std-Brief _____
27. EP-Brief _____
28. Std-Brief _____
29. Std-Brief _____
30. Std-Brief _____
31. EP-Brief _____
32. EP-Brief _____
33. EP-Brief _____
34. Std-Brief _____
35. Std-Brief _____
36. EP-Brief _____
37. Std-Brief _____
38. Std-Brief _____
39. EP-Brief _____
40. EP-Brief _____
41. Std-Brief _____

1/2

2/28/2018

42. Std-Brief _____
43. EP-Brief _____
44. EP-Brief _____
45. Std-Brief _____
46. EP-Brief _____
47. Std-Brief _____
48. EP-Brief _____
49. Std-Brief _____
50. EP-Brief _____
51. EP-Brief _____
52. Std-Brief _____
53. Std-Brief _____
54. Std-Brief _____
55. EP-Brief _____
56. EP-Brief _____

56 subjects randomized into 14 blocks
To reproduce this plan, use the seed 14456
Randomization plan created on 2/28/2018, 11:43:44 PM

Appendix 15: Simulation Study Flow

Participant ID: _____

Date: _____

DATA COLLECTION FLOW SHEET – RCT	
Orientation and Informed Consent	
	Greet participant in designated waiting area. And bring to conference room assigned.
	Reconfirm inclusion criteria using check off sheet and clarifying Team STEPPS training. <ul style="list-style-type: none"> ○ Must have been exposed to I-SBAR or SBAR during course work
	Explain the general flow of the data collection process. <ul style="list-style-type: none"> ○ Time to read and ask questions regarding the informed consent ○ Brief followed by active simulation followed by filling out a questionnaire about the active simulation experience. ○ Coffee card provided after completion of the questionnaire. ○ De-brief if requested but not part of the study or mandatory.
	Informed consent <ul style="list-style-type: none"> ○ Provide the participant the informed consent. ○ Answer any questions and obtain participants signature. ○ Ask if they would like a copy. Provide one if requested.
The Study - Brief	
	Present goals and objectives to participant <ul style="list-style-type: none"> ○ These are on a separate sheet of paper the participant may use to take notes and use in the encounter. ○ Review but do not ask for any questions or answer any questions. If the participant has questions respond that there will be a time for questions following the orientation.
	Provide an overview of the encounter <ul style="list-style-type: none"> ○ Explain that the simulation will last no more than 7 minutes. ○ This will be a manikin based simulation and the manikin will respond to any questions the participant may have. ○ Escort participant to the simulation environment and allow them to view and explore the environment for no more than 5 minutes. <ul style="list-style-type: none"> ▪ The monitors will be running but with different data from the actual simulation. ○ Escort them back to the conference room and provide the intervention assigned to the participant.

	Intervention - provided the appropriate intervention based on group assignment
	<p>(Traditional-Brief) - Control</p> <ul style="list-style-type: none"> ○ Allow the participant 10 minutes of unstructured time to prepare for the simulation.
	<p>(Facilitated Tutored problem Brief) - Treatment</p> <ul style="list-style-type: none"> ○ Participants spend 10 minutes as a structured facilitated example-based learning session for the simulation activity. The PI will ask the participants a series of questions designed to bring their knowledge in pieces together prior to the simulation activity. The opening questions for this component of the brief will be; <ul style="list-style-type: none"> a. “Let’s review what you know about I-SBAR handoff communication. What do each of the component parts of I-SBAR stand for?” <ul style="list-style-type: none"> i. Write I-SBAR on the white board b. “Where and how might you gather the information that will allow you to report a complete I-SBAR in the simulation environment you are about to enter?” c. “What difficulties do you anticipate you will encounter once you enter the environment and how might you plan to overcome them?” ○ Allow the participants to ask additional follow-up questions. ○ Allow the participant to spend any remaining time preparing however they wish for the encounter.
	The Active Simulation
	<p>After the brief, escort the participant to the simulation suite and begin the simulation activity. They may bring their provided clipboard and paper/pen</p> <ul style="list-style-type: none"> ○ The participant will have 5 minutes to interact with the environment ○ At the end of 5 minutes the monitors will go blank and a confederate will enter the room and ask for an I-SBAR on the patient. ○ The participants verbal I-SBAR will be audio-recorded.
	Leppink-Paas Scale
	<ul style="list-style-type: none"> ○ Escort the participant back to the conference room and have them fill out a Leppink-Paas Scale. ○ Once completed issue a coffee card to the participant and obtain their signature. ○ Offer them a short de-brief on their performance.

Appendix 16: Simulation Study Case Details

Participant ID# _____

Simulation Information

Objective:

- Assess patient for stability/ability to participate in out of bed activity (ambulating hallways, sitting up in a chair etc.)

Goals:

- Collect the needed information to verbally report a thorough patient update/handoff using the I-SBAR format.
- Provide a complete verbal I-SBAR to another team provider when prompted.

Background:

- 59 year old male/female
- Lives alone in the hills has many stairs from garage down to front door.
- Felt heart racing last night /got concerned and called 911 – ended up in hospital at 1:30 am.
- Independent in all activities but feels like he’s/she’s slowing down a bit, gets more “winded” over the past few months, more tired out.
- No cardiac history in the past but father died of “heart attack” in his 60’s and mother had a small stroke last year.
- Has not been out of bed since coming in to the hospital early this morning.
- Was just moved to a room with telemetry monitoring from the ED an hour ago.
- Medical diagnosis: Cardiac dysrhythmia – possible new onset a-fib.
- Current medical diagnosis: Cardiac dysrhythmia – possible new onset rapid a-fib.

NOTES:

Appendix 17: Simulation Study Design Details

1 State Qualitative description may be applied	Patient Status	Student learning outcomes or actions desired Trigger to move to next state	
STATE 1 - BASELINE <ul style="list-style-type: none"> • Alert and oriented • In bed • Concerned that they are in the hospital but able to answer all questions. • Lives alone in the hills has many stairs from garage down to front door. • Felt heart racing last night /got concerned and called 911 – ended up in hospital at 1:30 am. • Independent in all activities but feels like s/he’s slowing down a bit, gets more “winded” over the past few months, more tired out. • No cardiac history in the past but father died of “heart attack” in his 60’s and mother had a small stroke last year. • Hasn’t been OOB since coming in to the hospital. • The time is the actual time. • Just moved to room an hour ago from the ED. • Has had some kind of medication but not sure what – something to control my heart. 	Monitor Settings <ul style="list-style-type: none"> • <i>O2 sat 98</i> • <i>BP 134/80</i> • <i>HR 80’s- low 100’s</i> • <i>RR 17</i> • <i>NSR – sinus tachy</i> 	Expected Learner Actions: <ul style="list-style-type: none"> • Introduction AIDET <ol style="list-style-type: none"> (1) Announce (2) Introduce (3) Description (4) Expectation (5) Thankyou at end • Gather/clarify appropriate interview information regarding PLOF, family history and brief history of events. 	Sim Operator/Confederate Notes: <ul style="list-style-type: none"> • Simulation operator will play the patient and interact from the control room with the learner. Sim operator will answer all questions the learner asks. • If the learner does not initiate conversation the sim operator will ask the learner “I’m sorry I didn’t catch who you were”
	Patient Disposition <ul style="list-style-type: none"> • Cooperative but concerned, wants to get home ASAP 		Trigger to move to next State <ul style="list-style-type: none"> • Once it seems that student has attempted/completed interview/introduction....

2 State Qualitative description may be applied	Patient Status Physiologic parameters, disposition of patient	Student learning outcomes or actions desired Trigger to move to next state	
<p>STATE 2 – HR Increase</p> <p>Near the end of the interview patient responds saying;</p> <p>“there, I feel it. It’s racing – I feel my heart racing again and I’m just lying here”</p>	<p>Monitor Settings</p> <ul style="list-style-type: none"> • <i>O2 sat 98</i> • <i>BP 134/80</i> • HR 106-145 • RR 25 • <i>A-fib</i> 	<p>Expected Learner Actions:</p> <ul style="list-style-type: none"> • Captures dysrhythmia or increase in HR on monitor and acknowledges this to patient • Appropriately informs patient they will need to check in with their CI prior to getting OOB or up 	<p>Sim Operator/Confederate Notes:</p> <ul style="list-style-type: none"> • Keep runs going until student notices and has a chance to determine if the rhythm is stable for OOB activity • Continues to interact with the participant until the 5 minutes is over or until the participant reports they are ready to report their I-SBAR
	<p>Patient Disposition</p> <ul style="list-style-type: none"> • More concerned, a bit anxious but remains cooperative 		<p>Trigger to move to the next state:</p> <ul style="list-style-type: none"> • 5 minutes is over or until the participant reports they are ready to report their I-SBAR

3 State Qualitative description may be applied	Patient Status Physiologic parameters, disposition of patient	Student learning outcomes or actions desired Trigger to move to next state	
<p>STATE 3 - The I-SBAR</p> <p>The participant remains in the room and reports to the CI or PCP who enters their I-SBAR when prompted</p>	<p>Null at this point</p>	<p>Expected Learner Actions:</p> <p>The participant will report off their I-SBAR verbally to the CI/PCP</p>	<p>Sim Operator/Confederate Notes:</p> <ul style="list-style-type: none"> • At the end of 5 minutes the operator turns off the monitors and announces the simulation is over • They then enter the room and act as the CI or PCP etc. and ask "Can you give me an I-SBAR for this patient?" • Important: this I-SBAR interaction must be audio recorded not video recorded <p>Trigger to move to the next state</p> <p>Once the participant has finished their I-SBAR they are escorted to a de-brief and are asked to fill out the CL measurement survey</p>

Simulation Components:

Complexity (list all interacting elements)

- Room: standard hospital acute care room, bed, chair, over bed table, water pitcher, pt's tablet on table
- Manikin: O2 via nasal cannula, O2 sat monitor, BP cuff, ECG chest leads, wrist band, IV hep locked, pt resting in semi-fowlers position
- Monitor: O2 sat, BP, HR, ECG continuous, BP inflates during encounter on auto 1 time, When HR increases monitor alar sounds
- CI/PCP: participants have been introduced prior to sim activity, appropriate lab coat with clearly visual name tag and profession.

Fidelity

- Manikin based simulation with eye blink, chest rise and fall, and voice feed

Student Support

- Prior introduction to the environment, introduction to the sim operator/CI, communication with patient for questions answered, monitor alarm when HR increases,

Appendix 18: Simulation Study Informed Consent

General Informed Consent Form NSU Consent to be in a Research Study Entitled

Does Example Based Learning as a Tutored Problem Brief vs. a Standard Brief Improve Outcomes on Verbal Handoff Skills in Novice Health Professional Graduate Students? A Double Blind Controlled Study.

Who is doing this research study?

College: Department of Physical Therapy, College of Health Care Science, Health Professions Division

Principal Investigator: Susan Grieve, DPT, MPT, MS

Faculty Advisor/Dissertation Chair: Shari Rone-Adams, PT, MHSA, DBA

Co-Investigator(s): None

Site Information: Samuel Merritt University, 450 30th Street Oakland, CA 94609

Funding: Unfunded

What is this study about?

This is a research study, designed to test and create new ideas that other people can use. The purpose of this research study is to **determine how novice learners in graduate health professional education perform on verbal patient handoff skills using the I-SBAR format after participating in different types of simulation briefs before a simulation experience. Additionally, the study will determine if the different types of mental effort (cognitive load) experienced during the simulation activity correlate to performance on verbal patient handoff skills. Understanding this is important in helping educators better design simulation experiences to optimize learning and performance.**

Why are you asking me to be in this research study?

You are being asked to be in this research study because you are enrolled as a student one of the following graduate health professional programs at Samuel Merritt University; Doctor of Physical Therapy, Doctor or Master of Occupational Therapy, Entry Level Master of Nursing Science, Master of Physician Assistant or Doctor of Podiatric Medicine.

This study will include between 46 and 58 people. It is expected that all people enrolled in the study will be from the Samuel Merritt University campus in Oakland California.

What will I be doing if I agree to be in this research study?

While you are taking part in this research study you will be asked to participate in one session for approximately 60 minutes.

Research Study Procedures - as a participant, this is what you will be doing:

Upon arrival to the Health Science Simulation Center at SMU you will be provided a short 10 to 15 minute orientation by the principle investigator regarding the flow of the study and asked to read and sign this informed consent document. You will then participate in a brief with at least one other individual but no more than 3 additional individuals for 15-20 minutes. Once the brief is completed you will be escorted to the simulation activity. You will be provided a cue to enter the simulation activity and will participate in the encounter alone. The encounter will last five minutes with two minutes allocated for you to report your handoff assessment to an RN who will enter the simulation environment. Once you have completed the simulation activity you will be escorted to a debriefing room as asked to complete an eight-item survey. Once the survey form is collected data collection has ended and you will be offered an opportunity to participate in a closing debrief lasting up to 15 minutes. Participation in the closing brief is optional as it is not required for data collection in this study but is a standard of practice in all simulation experiences and recommended.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life. Although this simulated clinical experience is intentionally designed to attempt to match your current level of understanding, some individuals find participating in any simulated clinical experiences stressful and anxiety provoking. You will have the opportunity to de-brief this experience with experienced simulation de-briefers who will be able to help you understand your discomfort and make sense of the experience.

What happens if I do not want to be in this research study?

You have the right to leave this research study at any time, or not be in it. If you do decide to leave or you decide not to be in the study anymore, you will not get any penalty or lose any services you have a right to get. If you choose to stop being in the study, any information collected about you **before** the date you leave the study will be kept in the research records for 36 months from the conclusion of the study, but you may request that it not be used.

What if there is new information learned during the study that may affect my decision to remain in the study?

If significant new information relating to the study becomes available, which may relate to whether you want to remain in this study, this information will be given to you by the investigators. You may be asked to sign a new Informed Consent Form, if the information is given to you after you have joined the study.

Are there any benefits for taking part in this research study?

The benefits from being in this research study are that we hope the information learned from this study will help you more to be more aware of the mental efforts (cognitive load) you experience during a simulated learning activity. Additionally, we hope the experience of participating in the simulation brief, activity and debrief help you in perform better verbal handoffs in your future as a health care provider.

Will I be paid or be given compensation for being in the study?

You will be given a \$10.00 Starbucks coffee gift card once your survey form is collected and before you leave the simulation center. You must participate in the brief and simulation activity as well as complete the survey form to receive the gift card, but you do not need to participate in the de-brief.

Will it cost me anything?

There are no costs to you for being in this research study.

Ask the researchers if you have any questions about what it will cost you to take part in this research study (for example bills, fees, or other costs related to the research).

How will you keep my information private?

Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law and will be limited to people who have a need to review this information. The audio recordings or verbal handoff and survey responses will be kept in the locked office of the principle investigator (PI) at Samuel Merritt University (SMU). Once the audio recordings are scored they will be deleted permanently from the recorders. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any regulatory and granting agencies (if applicable). If we publish the results of the study in a scientific journal or book, we will not identify you. All confidential data will be kept securely in a locked file cabinet in the PI's office at SMU. This will include score sheets of hand off performance and surveys. All data will be kept for 36 months and destroyed after that time by placing the score sheets and survey sheets in a University paper shredder.

Will there be any Audio or Video Recording?

This research study involves audio recording. This recording will be available to the researcher, the Institutional Review Board and other representatives of this institution. The recording will be kept, stored, and destroyed as stated in the section above. Because what is in the recording could be used to find out that it is you, it is not possible to be sure that the recording will always be kept confidential. The researcher will try to keep anyone not working on the research from listening to the recording.

What Student/Academic Information will be collected and how will it be used?

None

Whom can I contact if I have questions, concerns, comments, or complaints?

If you have questions now, feel free to ask us. If you have more questions about the research, your research rights, or have a research-related injury, please contact:

Primary contact:

Susan Grieve, PT, MS, DPT can be reached at (510) 879-7384.

If primary is not available, contact:

Shari Rone-Adams PT, MHSA, DBA Committee Chair can be reached at (954) 262-1740. Please note Dr. Rone-Adams is located in Florida which is 3 hrs ahead of California time.

Gail Widener PT, PhD Chair, Samuel Merritt University Institutional Review Board for the Protection of Human Subjects (SMUIRB) can be reached at (510) 879-9200 x 7378

Research Participants Rights

For questions/concerns regarding your research rights, please contact:

Institutional Review Board
Nova Southeastern University
(954) 262-5369 / Toll Free: 1-866-499-0790
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Research Consent & Authorization Signature Section

Voluntary Participation - You are not required to participate in this study. In the event you do participate, you may leave this research study at any time. If you leave this research study before it is completed, there will be no penalty to you, and you will not lose any benefits to which you are entitled.

If you agree to participate in this research study, sign this section. You will be given a signed copy of this form to keep. You do not waive any of your legal rights by signing this form.

SIGN THIS FORM ONLY IF THE STATEMENTS LISTED BELOW ARE TRUE:

- You have read the above information.
- Your questions have been answered to your satisfaction about the research.

Adult Signature Section

I have voluntarily decided to take part in this research study.

Printed Name of Participant

Signature of Participant

Date

Printed Name of Person Obtaining
Consent and Authorization

Signature of Person Obtaining Consent &
Authorization

Date

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