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The Effects of Simulation-Based Training on Critical Thinking

by

Raiza Lee Dottin

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

Doctor of Education
in
Learning and Leading

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School of Education

2018

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The Effects of Simulation-Based Training on Critical Thinking

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Raiza Lee Dottin

This dissertation is completed as a partial requirement for the Doctor of Education (EdD) degree at the University of Portland in Portland, Oregon.

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Abstract

The purpose of this study was to examine the effects of a simulation-based training on the critical thinking skills of 10 graduate medical education trainees to understand the potential of simulation-based training as an innovative tool to improve medical competencies among trainees in a graduate medical training program. The theoretical framework incorporated in this study focused on the Five-Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus and the Theory of Andragogy by Malcolm Knowles to examine how adults learn in a medical simulation-based training setting. This study utilized a pre-and posttest, the AAC&U VALUE Critical Thinking Rubric, and individual interviews with trainees after the simulation. In analyzing pre/posttest scores, a paired samples t-test revealed that all 10 trainees showed a small growth in critical thinking regarding the management of a patient with cardiogenic shock based on hemodynamics by 0.30. A summary of the rubric study findings reported that third-year trainees received the highest critical thinking scores, while first-year trainees received the lowest critical thinking scores. Participant mean scores on the rubric also showed a correlation in the progression of training year to increased critical thinking in their use of hemodynamics to manage patient with cardiogenic shock. Post-simulation interviews with study participants reflected four major themes that included: (a) discrepancies in frequency and classification of simulation training, (b) the simulation learning environment, (c) from theory to practice, and (d) the impact of simulation training on clinical practice. The results of this study indicated the

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amount of prior exposure a trainee has to the medical competency that is being addressed in the simulation may have an influence on how the trainee perceives the value of the training. This study also found the amount of interaction that a rater has with the trainee may cultivate a bias in how they evaluate the trainee's procedural and theoretical knowledge. The researcher recommends the implementation of a cohesive simulation curriculum for graduate medical education training programs. The researcher also recommends providing trainees with adequate exposure to simulation that is meaningful, practical, and relevant to their training to elevate the trainees overall learning experience.

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Acknowledgments

I would like to acknowledge several individuals who were instrumental in the completion of my dissertation. To my mother and mother-in-law, who provided continuous words of encouragement on this journey, and always listened to my research related ramblings with absolute love and slight confusion.

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I also want to acknowledge the committee members who took the time to read and reflect on this work: Dr. Sally Hood, Dr. Ellyn Arwood, and Dr. Eric Anctil. Each of you brought a unique perspective to this research study, helping me understand the importance of a meaningful learning experience.

Finally, I appreciate each of the doctoral students in my cohort who have made this journey a fun and rewarding one. I especially want to thank Emily Jaskowiak, who checked in with me during every hour of our dissertation writing party weekends, providing motivational text messages and laughter along the way. Cohort three is no longer a group of classmates, but a family of support.

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Dedication

This dissertation would not have possible without my amazing husband, who always provided me with words of encouragement, a shoulder to cry on, and delicious fast food every time I came home late from class. He also reminded me each day to never give up and any frustrations I had during this process were only temporary. For that and a million other reasons, I love you and thank you for being next to me during this journey. I also want to dedicate this dissertation to my dog Lola, who sat next to me every night as I wrote page upon page and provided continuous snuggles as well as barks (and a few growls) of encouragement. You guys are awesome!

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Chapter One: Introduction to the Study

Once we realize that imperfect understanding is the human condition, there is no shame in being wrong, only in failing to correct our mistakes, (Soros, Wien, & Koenen, 1995, p. 11).

In an age when practicing physicians have access to an overwhelming volume of clinical information and are faced with increasingly complex medical decisions, the ability to execute sound clinical reasoning is essential to optimal patient care (Cooke & Lemay, 2017). However, problems with clinical reasoning in the medical setting (wrong, delayed, or missed diagnosis and/or treatment), make up a sizable portion of preventable adverse outcomes (Iobst, Trowbridge, & Philibert, 2013). A 2005 medical study regarding the contribution of cognitive components in diagnostic error involving injury or death concluded that 75% of cases were in part due to cognitive errors (Graber, Franklin, & Gordon, 2005). Cognitive factors such as misidentification of a patients' symptoms or a physician's insufficient knowledge of a relevant condition can have a major impact on patient care (Graber et al., 2005). Devising strategies for reducing cognitive error in the medical setting is imperative to the continuity of care for patients.

Background of the Problem

Medical errors related to clinical reasoning can often reflect a gap in a physician's cognitive process or metacognition (Graber et al., 2005). As stated by Croskerry (2000), proficiency in the cognitive domain, compared with proficiency in procedural skills, is less easily defined, involves a much broader range of possibilities, and would appear to be less easily taught in the medical education of physicians. The

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development of clinical reasoning in medical trainees has traditionally been left to clinical rotations. A clinical rotation is an educational experience of planned activities in selected settings, over a specific time period, developed to meet goals and objectives of the program (i.e. intensive care unit or consultation clinic) (ACGME Glossary of Terms, 2013). However, the current clinical setting can be restricted to limited practice and suboptimal supervision for a medical trainee (Schmidt & Mamede, 2015). Changes in healthcare delivery have resulted in fewer opportunities for medical trainees to learn from a breadth of real patients. Moreover, the changing roles of healthcare professionals have also reduced learning opportunities to practice (Khan, Pattison, & Sherwood, 2011). As asserted by Khan et al. (2011), the traditional apprenticeship model within medical education is no longer effective in the current clinical setting. Helping medical trainees become able diagnosticians is the most important objective of medical education (Schmidt & Mamede, 2015). Concurrently, the acquisition of clinical reasoning through the development of critical thinking skills should be an essential component of a physician's medical training (Maudsley & Strivens, 2000).

Critical thinking in graduate medical education. When discussing the desired outcomes of Graduate Medical Education (GME), it is common for program directors to voice the hope that their graduates will excel at critical thinking. However, the actual term 'critical thinking' is not directly stated in the six competencies designated by the Accreditation Council for Graduate Medical Education (ACGME), as defined in Table 1 of the ACGME Core Competencies in Graduate Medical Education.

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Table 1

ACGME Core Competencies in Graduate Medical Education

ACGME Competency Area	Performance Metric
Patient Care	Provide patient-centered care that is compassionate, appropriate, and effective for the treatment of health problems and the promotion of health.
Medical Knowledge	Established and evolving biomedical, clinical, epidemiological, and social-behavioral sciences, as well as the application of this knowledge to patient care.
Professionalism	Commitment to carrying out professional responsibilities and an adherence to ethical principles.
Interpersonal and communication skills	Effective exchange of information and collaboration with patients, their families, and health professionals.
Systems-based practice	Awareness of and responsiveness to the larger context and system of health care, as well as the ability to call effective on their resources in the system to provide optimal health care.
Practice-based learning and improvement	To investigate and evaluate one's care of patients, to appraise and assimilate scientific evidence, and to continuously improve patient care based on constant self-evaluation and life-long learning.

ACGME Milestones Guidebook for Residents and Fellows (2017)

Within the ACGME core competency of 'practice-based learning and improvement,' self-evaluation and life-long learning are terms used to define the performance metric of a medical trainee. While these terms are often synonymous with the concept of critical thinking (Krupat et al., 2011), the actual term, critical thinking, is not explicitly stated in this competency or in the other five competencies. Per Krupat et al. (2011), the absence of this formal reference in medical accreditation standards and goals can be partially accounted for by the adoption of more specific reference terms that have a clear overlap such as the Liaison Committee on Medical

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Education (2010) interest in 'critical judgment' and the UK General Medical Council's (2010) expectation that doctors should be able to integrate and critically evaluate evidence. Additionally, the attention given to so many other closely related concepts in connection to critical thinking, such as analytic reasoning, clinical and diagnostic reasoning, and problem-solving indicates that a great deal of interest exists in this broadly conceptualized domain (Krupat et al., 2011).

As iterated, within medical education training, the acquisition of the aptitude to reason clinically is traditionally learned in clinical rotations (Schmidt & Mamede, 2015). Learning during rotations is largely a process of learning by doing. However, opportunities to critically review one's own performance during clinical rotations is often limited. Supervision of a medical trainee in the ward can be of variable quality and feedback is not always consistent (Schmidt & Mamede, 2015). Further, the number and variety of patients available for practice can be limited based on the type of clinical service (Schmidt & Mamede, 2015). Given the number of limitations in the clinical setting, this can generate an inconsistency and potential bias in the assessment of a medical trainee's ability to utilize and refine their critical thinking skills when providing patient care (Jones, Passos-Neto, & Braghiroli, 2015). One way of addressing the gap in critical thinking skills among graduate medical trainees is through simulation-based training (Jones et al., 2015).

Simulation-based training in graduate medical education. Through the establishment of an academic society dedicated to simulation, the inauguration of a simulation journal, and the rapid increase of simulation-based literature and research, simulation has taken center-stage as the cornerstone of healthcare professional

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education and patient safety. The Association of American Medical Colleges acclaimed simulation-based training as the most prominent innovation in medical education over the past 15 years (Passiment, Sacks, & Huang, 2011). Growing research acknowledging the benefits of simulation-based training (McGaghie, Issenberg, Petrusa, & Scalese, 2010), along with recent fundamental changes in the delivery of medical education, have accelerated the application of simulation in today's medical education curriculum (Willis & Van Sickle, 2015). Moreover, simulation-based training has the potential to revolutionize healthcare and address patient safety issues if appropriately utilized and integrated into the medical educational and organizational improvement process (Gaba, 2004).

Within graduate medical education, high-fidelity medical simulation is used to teach high-risk skills. It mimics real scenarios more closely by providing a simulated patient (high-fidelity mannequin), and an environment that closely approximates a hospital's various patient care areas (Yeager et al., 2004). Medical simulation also allows for the integration of knowledge and skill without endangering patients. Per Bradley (2006), medical universities incorporating various simulation techniques can potentially increase their educational impact by having definable student learning and patient care outcomes. Furthermore, such universities create multidisciplinary and multi-professional learning environments for medical trainees (Ker, Mole, & Bradley, 2003). The use of a multitude of simulation techniques can enhance learning at various levels of training, tapping into many cognitive, psychomotor, and affective domains (Khan et al., 2011).

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In 2006, members of the Accreditation Council for Graduate Medical Education (ACGME) Residency Review Committee for Surgery (RRC-S) voted unanimously to require simulation-based training in surgical residency programs (Britt & Richardson, 2007). The ACGME RRC-S stated that practicing technical skills in a controlled, risk-free environment allows surgical trainees to develop and master surgical maneuvers safely. It also provides a means for objective, standardized assessment of skills performed by surgical trainees. Surgical programs were given two years to incorporate simulation-based education into their residency training curriculum, with the understanding that these requirements can be met with both low-technology and high-fidelity simulators (Britt & Richardson, 2007).

Fidelity in simulation has traditionally been defined as the degree that the simulator replicates reality (Beaubien & Baker, 2004). Using this definition, simulators are labeled as either ‘low’ or ‘high’ fidelity depending on how closely they represent ‘real life’ (Lewis, Strachan, & Smith, 2012). High-fidelity simulation allows participants to rehearse the clinical management of rare, complex, or crisis situations in a valid representation of clinical practice, before practicing on patients (Lewis et al., 2012). Many surgical residency training programs have implemented simulation boot camps that include low-fidelity simulation models to teach procedural skills such as suturing and airway management, as well as high-fidelity simulation, to learn endoscopy competencies and resuscitation management (Fernandez, Parker, Kalus, Miller, & Compton, 2007).

Alternatively, the current ACGME Program Requirements for Graduate Medical Education in Internal Medicine (2013), state that programs must provide

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trainees with access to training using simulation. However, the ACGME Review Committee (Internal Medicine General Subspecialty FAQs, 2014), does not expect each program to use a simulator or have a simulation center. According to the ACGME Residency Review Committee, medical simulation means that learning about patient care occurs in a setting that does not include actual patients (ACGME Internal Medicine General Subspecialty FAQs, 2014). This can include objective structured clinical examinations, patient simulators, or electronic simulation of codes, procedures, and other clinical scenarios. Per the ACGME Resident Review Committee in Internal Medicine, a training program can incorporate simulation and skills laboratories in any manner they believe adequate to address the competency goals of their educational program. Advanced Cardiac Life Support (ACLS), is an example of a simulation-based training that incorporates a computer-based exam and informational 10-minute simulation scenario to evaluate a trainee's ACLS competency skills. This would allow a program to be compliant with the requirement.

Per Gordon, Wilkerson, Shaffer, and Armstrong (2001), high-fidelity patient simulation may be a powerful new tool to bridge basic and clinical science, foster critical thinking, and enhance retention. Furthermore, through simulation-based medical training, a trainee can think through real problems under the pressure of a realistic simulation, without any real patient harm (Gordon et al., 2001). While simulation is often used as a tool to assess a medical trainee's procedural skills, it is often underutilized as a tool to evaluate critical thinking skills among graduate medical trainees (Aggarwal et al., 2010).

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Research Gap

Per Cleave-Hogg and Morgan (2002), an authentic learning experience through simulation can provide an environment that stimulates relevant prior knowledge and simultaneously transfers an awareness of any gaps in a trainee's current proficiency. Furthermore, authentic learning through simulation-based training can provide a disciplined focus on the learning process that encourages self-monitoring, can integrate into clinical tasks, and promotes deliberation about specific aspects of practice (Cleave-Hogg & Morgan, 2002). Per Varutharaju and Ratnavadivel (2014), the inclusion of clinical simulation in medical education should facilitate a holistic form of learning, fueled by active participation and interaction. Moreover, the simulation experience should be geared towards a self-directed approach where assessment is done authentically (Varutharaju & Ratnavadivel, 2014). However, per the ACGME, the way a graduate medical education program utilizes simulation-based training is at their discretion (ACGME Internal Medicine General Subspecialty FAQs, 2014). In its current state, simulation in graduate medical education is often promoted as a tool for skill proficiency and underutilized as a mechanism to improve a trainee's critical thinking skills (Cleave-Hogg & Morgan, 2002; Daniel-Underwood, 2016; Varutharaju & Ratnavadivel, 2014).

While simulation-based training is increasing in popularity as a teaching strategy in many medical schools across the United States, locating research related to the improvement of critical thinking skills through medical simulation-based training is difficult (Daniel-Underwood, 2016). Studies related to simulation-based training in medical education often gravitate their focus toward the efficiency of clinical

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simulation in achieving clinical competence (Bradley, 2006; Fernandez et al., 2007; Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005). However, the analysis of how learning takes place within the simulation-based environment, specifically, the integration of critical thinking skills within this setting, remains to be explored (Daniel-Underwood, 2016).

Purpose of the Study

The purpose of this study was to investigate the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees to understand the potential of simulation-based training as an innovative tool to improve medical competencies among trainees in a graduate medical training program.

Research Questions

To examine the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees, three research questions guided this study:

1. How do the participant's rate on critical thinking skills on the AAC&U Critical Thinking VALUE Rubric (2009) as revealed by their actions during a simulation?
2. What is the effect of simulation-based training on participants' critical thinking skills?
    a. As revealed through participant pre/posttest scores?
    b. As revealed through interviews with participants regarding their perspective on a simulation experience?

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3. After the simulation, how do participants describe the impact of participating in a simulation-based training on their clinical practice?

Significance of Study to Graduate Medical Education

The Association of American Medical Colleges (2014), supports the use of simulation-based training as a training tool that facilitates psychomotor tasks, leadership, team training, and critical thinking/decision making. Additionally, the American Board of Internal Medicine (ABIM) recommends that residents receive simulation training before performing invasive procedures on patients (ABIM Internal Medicine Certification Policies, 2017). While there is a vast amount of medical education research that conveys the positive aspects of incorporating simulation-based training in medical training programs (Beaubien & Baker, 2004; Daniel-Underwood, 2016; Fernandez et al., 2007; Jones et al., 2015; Khan et al., 2011; Lewis et al., 2012), research related to the impact of simulation-based training on the critical thinking skills of graduate medical education trainees is minimal. As a result, there is a need to establish a direct link between simulation-based training and critical thinking in graduate medical education. The goal of this study was to understand the potential of simulation-based training as a tool to improve medical competencies among trainees in a cardiovascular graduate medical training program.

Theoretical Framework

The theoretical framework incorporated in this study focused on two adult learning theories that examined how adults learn, with the purpose of analyzing its effects on the critical thinking skills of 10 graduate medical trainees in the medical education setting. The first theoretical framework utilized in this study is the Five-

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Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus (1980), states that individuals must progress through each stage of expertise and must draw on their experiences of solving problems in context to reach higher levels of expertise. The Dreyfus and Dreyfus Five-Stage Model of Adult Skill Acquisition (1980) is currently the basis for competency assessment among graduate medical trainees as modeled in the ACGME Internal Medicine Milestones. The Internal Medicine (IM) Milestones (2017) are competency-based developmental outcomes (e.g., knowledge, skill, attitudes, and performances), that can be demonstrated progressively by residents and fellows from the beginning of their education through graduation to the unsupervised practice of their specialties. This framework is outlined further in chapter two of this study.

The second theoretical framework utilized in this study is Malcolm Knowles Theory of Andragogy (1968), also known as Adult Learning Theory. The term andragogy was coined in the 1800s by Alexander Knapp, a German educator, to refer to methods or techniques used to teach adults and was popularized in 1968 by Malcolm Knowles. Knowles (1980), advocated for andragogical methods that focused on the adult learner's need to know, self-concept, experience, readiness to learn, orientation to learning, and motivation. Knowles (1980), also believed the adult learning process was important, held a willing, experimental, and innovative attitude toward helping learners learn from their mistakes, and provide learners with opportunities to practice self-direction. This framework is outlined further in chapter two of this study.

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Definition of Terms

The following are definitions to clarify key terms used in this dissertation:

ACGME. The Accreditation Council for Graduate Medical Education is a private professional organization responsible for the accreditation of about 9,200 residency education programs (ACGME Glossary of Terms, 2013).

Assessment. As defined by Epstein (2007), assessment is the measurement of capabilities of learners "providing motivation and direction for future learning" (p. 388). An example of assessment within medical education is multisource feedback that incorporates assessments by peers, other members of the clinical team, and patients to provide insight into trainees' work habits, capacity for teamwork, and interpersonal sensitivity.

Critical thinking. As defined by Facione and Facione (1996), critical thinking is "purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations that judgment is based on" (p. 2). Similarly, Norman (2005), defines critical thinking within medical education as "complex and multidimensional components of knowledge and skills used to solve patient problems to achieve effective care" (p. 426).

Competencies. The Accreditation Council for Graduate Medical Education Glossary of Terms (2013), defines competencies as specific knowledge, skills, behaviors and attitudes and the appropriate educational experiences required of residents to complete GME programs. These include patient care, medical knowledge,

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practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice.

Fellow. The Accreditation Council for Graduate Medical Education Glossary of Terms (2013), defines a fellow as a physician in a program of graduate medical education accredited by the ACGME who has completed the requirements for eligibility for first board certification in the specialty.

Graduate Medical Education. The Accreditation Council for Graduate Medical Education Glossary of Terms (2013), defines graduate medical education as the period of didactic and clinical education in a medical specialty that follows the completion of a recognized undergraduate medical education and prepares physicians for the independent practice of medicine in that specialty, also referred to as residency or fellow education. The term "graduate medical education' also applies to the period of didactic and clinical education in a medical subspecialty that follows the completion of education in a recognized medical specialty and prepares physicians for the independent practice of medicine in that subspecialty.

Graduate-Year Level. The Accreditation Council for Graduate Medical Education Glossary of Terms (2013), defines graduate-year level as a resident's or fellow's current year of accredited GME. This designation may or may not correspond to the resident's year in a program (ACGME Glossary of Terms, 2013). For example, a resident in pediatric cardiology could be in the first program year of the pediatric cardiology program, but in his/her fourth graduate year of GME (including the three prior years of pediatrics). Also referred to as 'post-graduate year' or 'PGY'.

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High-fidelity medical simulation. As defined by Cant and Cooper (2010), high-fidelity simulation incorporates a computerized full-body mannequin that can be programmed to provide a realistic physiological response to student actions. Moreover, high-fidelity simulation can provide participants with a learning environment that is safe and controlled. In this environment, participants can make mistakes, correct those mistakes in real time, and learn from them without fear of compromising patient safety (Lewis et al., 2012).

Medical error. Defined by Donaldson, Corrigan, and Kohn (2000), as "injuries caused by medical management" (p. 210).

Resident. The Accreditation Council for Graduate Medical Education Glossary of Terms (2013), defines a resident as "any physician in an accredited graduate medical education program, including interns, residents, and fellows" (p. 8).

Summary

The inability of a medical trainee to recognize and process critical information can lead to patient injury, delay of care, inaccurate diagnosis, and ineffective treatment plans. Medical simulation offers the opportunity for graduate medical education trainees to foster their decision-making process, integrate their knowledge and expertise to solve patient problems, and achieve safe and effective patient care. Moreover, the ability of a graduate medical education program to determine the level of the trainee's capacity to think critically can allow for intervention prior to unsupervised patient encounters as they progress through their training.

This study aimed to investigate the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees to

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understand the potential of simulation as an innovative tool to improve medical competencies among trainees in a graduate medical training program. This chapter provided a background of how critical thinking is defined within medical education and discussed the way simulation is currently utilized within graduate medical education. Further, this chapter demonstrated a research gap in the examination of simulation-based training and critical thinking among graduate medical education trainees through the analysis of related research. The problem statement, research questions, and significance of this study in graduate medical education are also stated in this chapter.

Chapter Two includes a review of the literature, provides an overview of the construct of critical thinking, and examines simulation-based training within graduate medical education. Chapter Two also provides an analysis of the theoretical frameworks utilized in this study and makes a connection to critical thinking among graduate medical trainees. Chapter Three details the methods used in this study to examine the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical trainees through the implementation of a pre/posttest, critical thinking rubric, and post-simulation interviews. Chapter Four gives a summary of results for this study through a triangulation of the three areas of data collected. This study concludes in Chapter Five with a discussion of the significance of the findings of this study within graduate medical education. Chapter Five also provides implications for future research and recommendations regarding the implementation of simulation-based training to improve critical thinking and medical competencies among trainees in graduate medical training programs.

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Chapter Two: Review of the Literature

This chapter presents a review of the literature with a fourfold purpose: (a) synthesize the literature relevant to the concept of critical thinking within general education and graduate medical education; (b) provide a history of simulation-based training in various fields as well as graduate medical education; (c) review recent studies that utilize simulation-based training as an assessment tool; and, (d) review the Five-Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus (1980), as well as the Theory of Andragogy by Knowles (1980), that serve as the theoretical framework for this study.

Critical Thinking

This section addresses the definition of critical thinking and the development of critical thinking skills among trainees through the parameters of general education as well as graduate medical education. The purpose of this section is to provide the reader with a broader understanding of critical thinking as it relates to learning and development within graduate medical education through the review of current literature and related studies.

Critical Thinking in Education

Developing critical thinking skills needed for success beyond the classroom has been recognized as a primary goal of colleges and universities (Astin, 1993; Gellin, 2003; Stedman & Adams, 2012). In a survey conducted by the Association of American Colleges and Universities (2011), of 433 higher education institutions, 95% of the chief academic officers identified critical thinking as one of the most important skills for students. Beyond the higher education classroom, the preference of a

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knowledge-based economy over a once-dominant manufacturing economy means that positive outcomes are dependent on critical thinking abilities (Nold, 2017). Per Nold (2017), the critical thinking skills of an employee can be one of the strongest predictors of long-term success in the workplace.

In the evaluation of various critical thinking frameworks to identify common elements, Liu, Frankel, and Roohr (2014) reported that critical thinking involves much more than accumulating information or processing information. Rather, critical thinking involves identifying, analyzing, synthesizing, and evaluating information to yield actionable knowledge to make effective decisions (Argyris, 1996; Giancarlo & Facione, 2001; Liu et al., 2014; Scriven & Paul, 2004). Similarly, Alwehaibi (2012), defines critical thinking as the ability not just to acquire knowledge but also to make sense of new information. According to Halpern (1996), when people think critically, they are evaluating the outcomes of their thought process – how good a decision is or how well a problem is solved.

Within general education, critical thinking skills are often referred to as higher-order thinking skills to differentiate them from simpler (i.e. lower-order), thinking skills (Halpern, 1998). Higher-order thinking skills are relatively complex; they require judgment, analysis, and synthesis, and are not applied in a rote or mechanical manner (Halpern, 1998). Per Halpern (1998), computational arithmetic is not an example of higher-order thinking skills because it involves the rote application of well-learned rules with little concern for context or other variables that would affect the outcome. By contrast, deciding between two information sources is more credible is a higher-order thinking skill, because it is a judgment task where the variables affect

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credibility, is multidimensional, and changes with the context. As stated by Halpern (1998), "In real life, critical thinking skills are needed whenever people grapple with complex issues and messy, ill-defined problems" (p. 451).

The more common metacognitive framework related to critical thinking incorporated in U.S. classrooms is Bloom's taxonomy (Athanassiou, McNett, & Harvey, 2003). Bloom (1956) developed a taxonomy for educational objectives. Specifically, his work to classify statements of learner expectations (educational objectives), was created as a way to facilitate an exchange of test questions, measuring the same educational objective. With the aid of measurement specialists, six categories were developed (Bloom et al, 1956). The six cognitive domain categories were ordered from simple to complex and concrete to abstract. These categories were (from lowest to highest): *Knowledge, Comprehension, Application, Analysis, Synthesis*, and *Evaluation*. Figure 1 describes the six categories of Bloom's Taxonomy.

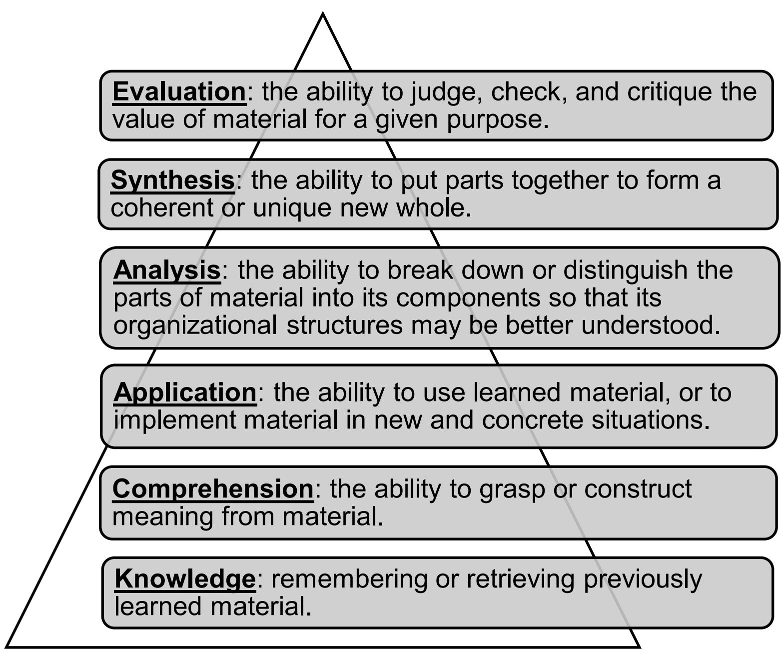

Figure 1. Bloom's six categories of cognitive taxonomy (1956).

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In 2001, Anderson and Krathwohl revised Bloom's Taxonomy to reflect a two-dimensional framework: knowledge and cognitive processes. In the revised taxonomy, the original number of categories (six) was retained, but with important changes. Three categories were renamed, the order of two were interchanged, and those category names retained were changed from noun to verb form to fit the way they are used in learning objectives. The original *Knowledge* category was kept as the first of the six major categories but was renamed *Remember*. *Comprehension*, the second of the original categories, was renamed *Understand*, in an effort to use a widespread synonym for comprehending (Anderson & Krathwohl, 2001). *Application, Analysis*, and *Evaluation* were retained but changed to verbs as *Apply*, *Analyze*, and *Evaluate*. *Synthesis* changed places with *Evaluation* and was renamed *Create*. Like the original Taxonomy, the revision is a hierarchy in the sense that the six major categories of the cognitive process dimension are believed to differ in their complexity, with *Remember* being less complex than *Understand*, less complex than *Apply*, and so on. Figure 2 describes the six categories of Revised Taxonomy by Anderson and Krathwohl (2001).

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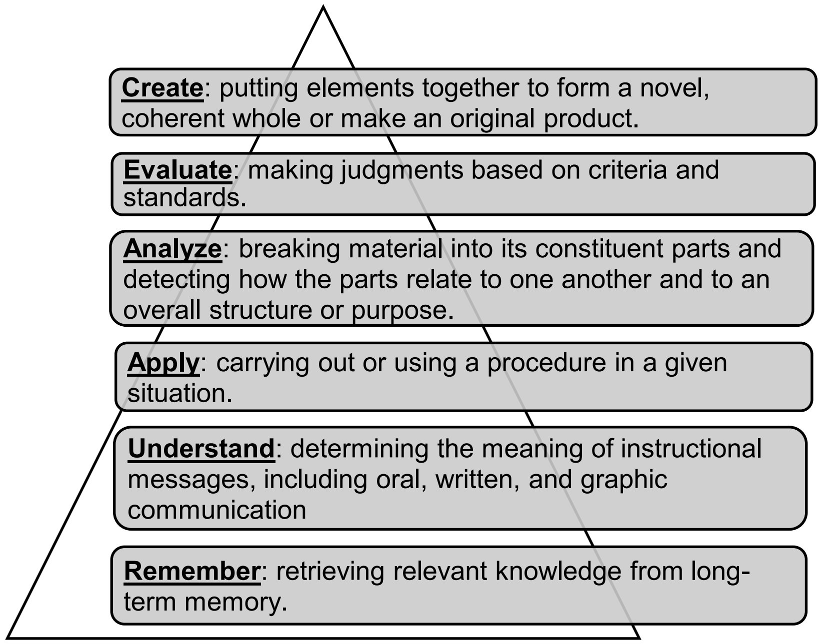

Figure 2. Anderson and Krathwohl six categories of revised taxonomy (2001).

Per Athanassiou, McNett, and Harvey (2003), Bloom's taxonomy can be used as a scaffolding device that requires students to determine the level of his/her work and from that self-analysis allows them to use the taxonomy to support their own higher-level thinking. Furthermore, the incorporation of Bloom's taxonomy within a curriculum can foster critical thinking and facilitate higher-order processing among students (Athanassiou et al., 2003). However, Bloom's taxonomy has received criticism for this type of learning. The major problems critics found with the original taxonomy design was that its levels are not always distinct and the underlying structural principle—increasing complexity—was naïve (Furst, 1981). In response to this argument, Athanassiou et al. (2003) state that the revised taxonomy is a still a useful tool in helping educators discover a student's level of metacognition or can at least be a useful first step. The revised taxonomy has also shown an integration within medical education as utilized by Plack et al. (2007), to assess the level of cognitive

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processing evident in the journals of 21-third-year medical students. In their study results, Plack et al. (2007) reported the revised taxonomy was a reliable method to assess deeper learning among medical students.

Critical Thinking in Graduate Medical Education

Per Huang, Lindell, Jaffe, and Sullivan (2016), critical thinking is a fundamental skill for clinicians. Critical thinking plays an essential role in clinical decision making and has implications for diagnostic accuracy, appropriate management, and patient outcomes (Huang et al., 2016). Huang, Newman, and Schwartzstein (2014), define critical thinking within medical education as the ability to apply higher cognitive skills (e.g. analysis, synthesis, self-reflection, perspective-taking), and/or the disposition to be deliberate about thinking (being open-minded or intellectually honest), that leads to action that is logical and appropriate. Per Huang et al. (2014), critical thinking is a fundamental skill for health professionals in practice due to the complex nature of healthcare delivery that demands clinicians gather, integrate and act upon constantly changing data. With this said, Huang et al. (2014), make the argument that deficits in a physician's critical thinking can have significant implications for patients, including misdiagnosis, delays in diagnosis, treatment errors and lack of patient-centered care.

Recent medical reports have also stressed the impact of medical errors in healthcare (Mamede, Schmidt, & Rikers, 2007). The adverse effects of a physician's mistakes have been pointed out as important causes of morbidity and mortality in healthcare (Bion & Heffner, 2004). The Institute of Medicine report, 'To Err is Human' (Kohn, Corrigan, & Donaldson, 1999), estimated that in the U.S., between

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44,000 and 98,000 patients die every year as a result of clinical errors. In 2013, the numbers of patient mortality increased to more than 250,000 deaths per year (Makary & Daniel, 2016). Per Kohn et al. (1999), one of the sources of medical error is poor clinical judgment.

Clinical judgment can be defined as the exercise of reasoning under uncertainty when caring for patients (Redelmeier, Ferris, Tu, Hux, & Schull, 2001). Per Redelmeier et al. (2001), a critical feature of clinical judgment is that physicians do not act solely on an arbitrary basis. Instead, clinical judgment should combine scientific theory, personal experience, patient perspectives, and other insights to provide optimal patient care (Redelmeier et al., 2001). Examples of clinical judgment in medicine range from the monumental (such as whether to discontinue life-support for a patient) to the banal (such as whether to discontinue a phone call when on hold with nephrology). Redelmeier et al. (2001) state, "Mistakes are made in clinical judgment because medicine is a demanding human endeavor" (p. 360). Furthermore, Redelmeier et al. (2001) state, "Flawless intellectual reasoning, diligent checking for errors, and foolproof environmental safeguarding would require superhuman talent" (p. 360).

In general education, critical thinking is often thought of as higher-order cognitive skills (Halpern, 1998), but in the realm of medical education, critical thinking is linked to clinical judgment (Redelmeier et al., 2001). Regardless of the terminology, critical thinking can encompass an array of cognitive skill and judgment (Alwehaibi, 2012; Halpern, 1998; Liu, Frankel & Roohr, 2014; Nold, 2017). Specifically, within medical education, critical thinking is a complex process that

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encompasses the interpretation of findings within a situation (Huang et al., 2016; Redelmeier et al., 2001). Per the National Council for Excellence in Critical Thinking (Scriven & Paul, 1987), the definition of critical thinking can vary according to the motivation behind it. Furthermore, critical thinking of any kind is never universal in any individual; everyone is subject to episodes of undisciplined or irrational thought (Scriven & Paul, 1987).

Assessment of Critical Thinking in Graduate Medical Education

Per Huang et al. (2016), the examination of accreditation standards in the health profession shows a wide variation in the degree that critical thinking is integrated. Some accrediting organizations depict critical thinking, clinical reasoning, or other related concepts as central to the work of health professionals (Barnes, Gale, Kacmarek, & Kageler, 2010; Greiner & Knebel, 2003; O'Sullivan, Blevins-Stephens, Smith, & Vaughan-Wrobel, 1997), whereas others mention these constructs in passing or not at all (ACGME, 2013; LCME, 2010). As discussed in Chapter One, the attention given to so many other closely related concepts such as analytic reasoning, clinical and diagnostic reasoning, and problem-solving indicates that a great deal of interest exists in this broadly conceptualized domain (Krupat et al., 2011). Despite an interest from clinical educators to address critical thinking, Krupat et al. (2011), state that critical thinking suffers from a lack of conceptual clarity in medical education.

In a qualitative content analysis study conducted by Krupat et al. (2011), 97 clinical-educators from five medical schools were surveyed regarding their definition of critical thinking and its application to clinical practice. Through this study, Krupat et al. (2011), found three ways that respondents framed the definition of critical

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thinking. The most common way the participants framed critical thinking was as a process ($n = 42$). The second way the participants framed critical thinking was as a 'skill' or 'ability' ($n = 40$). Both the 'process' and 'ability' frames stated by participants made consistent references to higher-order mental activities (e.g. synthesis, analysis, interpretation), involved in making sense of information (Krupat et al., 2011). The third way that participants framed critical thinking referred to the characteristics of a trainee, that incorporates personality traits, and habits of mind ($n = 6$), rather than a process or an ability (Krupat et al., 2011).

Per the study results, Krupat et al. (2011), state that defining critical thinking within medical education as a process or an ability suggests that, like other skills, it can be 'taught' and 'learned' through some form of instruction. However, conceptualizing critical thinking as a variable disposition among trainees has very different implications about what lies at its heart, where it comes from, and whether it is appropriate to conceive of it as a simple, 'teachable skill' (Krupat et al., 2011). Furthermore, study findings by Krupat et al. (2011), highlight a significant disconnect between the way that medical education conceptualizes critical thinking (i.e. in their frameworks), and the ways that critical thinking is distinguished in the clinical setting.

Per Scott et al. (1998), critical thinking depends on a medical trainee's ability to ask discriminating questions based on searches for better ideas and decisions in the clinical setting. These skills are acquired or enhanced through an active process of learning and practice (D'Angelo, 2002). On the ward, the medical trainee has continuous patient interactions and is required to apply their knowledge of disease (Schmidt & Mamede, 2015). Thus, learning during rotations is largely a process of

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learning by doing. However, opportunities for a medical trainee to critically review their performance is limited. Supervision of medical trainee in the ward can be of variable quality and feedback is not always consistent. Further, the number and variety of patients available for practice can be limited to a medical trainee as well (Schmidt & Mamede, 2015).

A study conducted by Rattner et al. (2001), comparing the clinical experiences of 647 third-year medical trainees, reported fewer than half of the trainees were exposed to patients with medical problems that have a high prevalence rate. Rattner et al. (2001), found that only 6% of trainees encountered a patient with a peptic ulcer during their clinical training. Peptic ulcers are considered a common medical problem that has high prevalence rates as reported by the Center for Control and Prevention. Per the study results, Rattner et al. (2001), make the argument that exposing medical trainees to an array of clinical experiences in the hospital and ambulatory settings during training is essential not only to the cultivation of a medical trainee's clinical reasoning, but the assessment of their clinical reasoning as well.

Within the arena of medical education, it is generally acknowledged that assessment drives learning (Ferris & O'Flynn, 2015). Along these lines, Liu and Carless (2006), state that assessment is one of the most significant influences on a student's experience in higher education. Thus, improving assessment has a significant impact on the quality of learning (Liu & Carless, 2006). To assess the critical thinking abilities of medical students, it is important to establish clear criteria for assessment (Zayapragassarazan, Menon, Kar, & Batmanabane, 2016). Epstein (2007), states that the function of assessment in medical education has three main goals: to optimize the

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capabilities of all trainees, to protect the public by identifying incompetent physicians, and to provide a basis for choosing applicants for advanced training (i.e. residency and fellowship). Ideally, the assessment of a medical trainee's competence should provide insight into their actual performance in the clinical setting as well as their capability to adapt to change and generate new knowledge (Fraser & Greenhalgh, 2001).

The assessment of medical residents, fellows, and increasingly of medical students, is largely based on a model that was developed by the Accreditation Council for Graduate Medical Education (ACGME). The ACGME is the accrediting body for a majority of graduate medical training programs for physicians in the U.S. Graduate medical training programs include residency and fellowship programs, defined in chapter one. The ACGME (2017) training model uses six interrelated domains of medical competence (outlined in Table 1 in chapter one) to assess the clinical competency of graduate medical trainees; medical knowledge, patient care, professionalism, communication and interpersonal skills, practice-based learning and improvement, and systems-based practice. A key distinguishing feature of competency-based education and training is that medical trainees can progress through the educational process at different rates (ACGME Milestones Guidebook, 2017). Furthermore, the most capable and talented medical trainee should be able to make career transitions earlier, while others may require more time (up to a point) to attain a sufficient level of knowledge, skills, and attitudes in order to enter unsupervised practice as specialized physicians (ACGME Milestones Guidebook, 2017).

Per Batalden, Leach, Swing, Dreyfus, and Dreyfus (2002), the ACGME is particularly focused on the progression of medical trainees moving from well-prepared

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and functioning advanced beginners (medical school graduates), to fully competent physicians. Commissioned by the U.S. Air Force to describe the development of the knowledge and skill of a pilot, Stuart Dreyfus and Hubert Dreyfus (1980), developed a model consisting of five stages: novice, advanced beginner, competent, proficient, and expert (Batalden et al., 2002). Table 2 describes each stage as it applies directly to medical education.

Table 2

Dreyfus Model of Knowledge Development

Skill Level	Components
Novice	The freshman medical student begins to learn the process of taking a history and memorizes the elements, chief complaint, history of the present illness, review of systems, and family and social history.
Advanced Beginner	The junior medical student begins to see aspects of common situations, such as those facing hospitalized patients (admission, rounds, and discharge) that cannot be defined objectively apart from concrete situations and can only be learned through experience.
Competent	The resident physician learns to plan the approach to each patient's situation. Risks are involved, but supervisory practices are put in place to protect the patient. Because the resident has planned the care, the consequences of the plan are knowable to the resident and offer the resident an opportunity to learn.
Proficient	The specialist physician early in practice struggles with developing routines that can streamline the approach to the patient. Managing the multiple distracting stimuli in a thoughtful way is intellectually and emotionally absorbing.
Expert	The specialist physician early in practice struggles with developing routines that can streamline the approach to the patient. Managing the multiple distracting stimuli in a thoughtful way is intellectually and emotionally absorbing.

Batalden et al., 2002

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Currently, within graduate medical education, the Dreyfus Model of Knowledge Development (1980) is known as Milestones (ACGME Milestones Guidebook, 2017). In general terms, a milestone is a significant point in a medical trainee's development of skill and comprehension within their specialty (ACGME Milestones Guidebook, 2017). The ACGME Milestones (2017), provide narrative descriptors of the competencies and sub-competencies along a developmental continuum with varying degrees of granularity. Simply stated, the ACGME Milestones (2017), describe performance levels that residents and fellows are expected to demonstrate in relation to skill, knowledge, and behaviors in the six clinical competency domains. Per the ACGME Milestone Guidebook (2017), the milestones describe the learning trajectory within a competency that takes a resident or fellow from a beginner in the specialty, followed by a highly proficient resident, ending at a fellow or early practitioner. The ACGME Milestones (2017), provide the framework that all GME programs must adhere to for accountability so that graduating residents and fellows across the US attain a prominent level of competency. Table 3 provides a general description of the ACGME Milestone (2017) levels.

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Table 3

General Description of ACGME Milestone Levels

Skill Level	Components
Level 1	What are the expectations for a beginning resident or fellowship?
Level 2	What are the milestones for a resident who has advanced over entry, but is performing at a lower level than expected at mid-residency or fellowship?
Level 3	What are the key developmental milestones mid-residency or fellowship? What should they be able to do well in the realm of the specialty at this point?
Level 4	What does a graduating resident or fellow look like? What additional knowledge, skills and attitudes have they obtained? Are they ready for certification?
Level 5	Stretch goals – Exceeds expectations

ACGME Milestones Guidebook, 2017, p. 5

While the ACGME Milestones (2017), lay out a framework of observable behaviors and other attributes associated with a resident's or fellow's development as a physician, the ACGME advise that the milestones should not describe or represent the totality or complete description of a clinical discipline. Specifically, the ACGME Milestones (2017), represent the important core of a discipline within graduate medical education, however, residency and fellowship programs should use good judgment to fill in the gaps of curriculum and assessment. Furthermore, the ACGME state that it is essential that the milestones are not thought of as curricula in and of themselves, but rather, they should guide a thoughtful analysis of curriculum to identify strengths and gaps in the clinical knowledge of a graduate medical trainee (ACGME Milestones Guidebook, 2017).

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The ACGME Milestones are not without criticism. Per Croskerry, Chisholm, Vinen, and Perina (2002), the ACGME Milestones have several limitations. An emerging concern in graduate medical education in recent years has been the lack of emphasis on thinking strategies (problem-solving, clinical decision making) and critical thinking skills (Croskerry et al., 2002). Croskerry et al. (2002), state that much of graduate medical education is aimed at acquisition rather than the application of knowledge. To aid in this assertion, Croskerry et al. (2002), highlight a study conducted by Macpherson in 2002, regarding the examination of problem-solving ability and cognitive maturity of undergraduate students at a university. Of the 173 undergraduate students surveyed, 20% of the participants reported they did not feel like they had achieved sufficient cognitive maturation to be able to think at the conceptual level required for problem-solving (Macpherson, 2002). While touching upon a different student demographic through the Macpherson (2002) study, Croskerry et al. (2002) stated that the impact of that study might be considerable in graduate medical education, where clinical problem-solving skills and the ability to detect cognitive bias in decision-making are so critical. Additionally, Croskerry et al. (2002), make the argument that because a sizable portion of graduate medical trainees lack a prominent level of critical thinking in their specialty when beginning a training program, many require direct supervision during their training to assess their critical thinking skills in the clinical setting.

According to Epstein (2007), the observations and impressions of supervising attendings of medical trainees remain the most prominent method used to evaluate a trainee's performance in the clinical setting. Graduate medical trainees most

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commonly receive global ratings at the end of a rotation or clinical training month, with comments from a variety of supervising physicians (Epstein, 2007). Although subjectivity can be a problem in the absence of articulated standards (i.e. ACGME Core Competencies), a critical issue with this assessment method is that the direct observations of trainees while they are interacting with patients can be infrequent Epstein (2007). This issue was examined in a study conducted by Pulito, Donnelly, Plymale, and Mentzer, Jr. (2010), who reported that the attending evaluations of medical trainees at a university were unreliable due to the infrequent time the attending spent with the medical trainees. Moreover, providing formative feedback during busy rotations, particularly when a student spent as little as two weeks rotating on a specialty service, was dismal (Pulito et al., 2010).

Another method of assessing a medical trainee's clinical competency that Epstein (2007) examines is simulation-based training. The next section provides a history of simulation training in general education as well as in medical education. Additionally, the section provides a review of studies that focus on the assessment of critical thinking in medical education through the use of simulation-based training.

Simulation-Based Training

This section provides a brief historical background of the use of simulation training in education. This section also provides a historical background of the use of simulation in graduate medical education as well as reviews studies that highlight simulation-based training as a method to increase or assess critical thinking. The purpose of this section is to provide the reader with an understanding of the methods

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currently utilized by graduate medical programs to incorporate simulation-based training as a tool to address critical thinking among trainees.

Simulation-Based Training in Education

Simulation has had a long and varied history in many different education and training fields (Aebersold, 2016). In aviation and the military, simulation has become part of the common process of training and certification (Aebersold, 2016). The first successful use of simulation in aviation began in the late 1920s with the development of the Link trainer. Per Aebersold (2016), one of the distinct advantages of the Link trainer was its ability to teach pilots how to fly using instruments. A pilot could practice their skills in flying "blind" through instrument training. The US Army Air Corps soon recognized this type of training as a safer method in contrast to their current training approach (Aebersold, 2016). The Link trainer was the beginning of the commercial use of simulators for training in aviation, and thus an industry was born. In 1979, simulation in aviation reached its 50-year anniversary, and the majority of pilot training was done in simulators (Aebersold, 2016). Today, pilots are still trained in simulators; the first time a pilot lands a commercial airplane, he/she does it with a check pilot next to him/her and a full load of passengers on board (Aebersold, 2016).

Simulation and war games have also been long used in the military to engage in battle strategies (Aebersold, 2016). A war game is a simulated battle or campaign to test military strategy. The Roman commanders used sand tables to plan battle strategies using miniature soldiers representing different armies (Aebersold, 2016). In 1664, Weikmann created a board game called Koenigspiel or "war chess" (Aebersold, 2016). This game was developed specifically to train military personnel in

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communication skills and the basics of military art and science (Aebersold, 2016). Kriegsspiel, another board game developed in 1811 for the military, focused on improving military thinking and strategy (Aebersold, 2016). Today, the military uses simulations and war games for training in many areas and is very advanced in this area.

Immersive simulations and serious games in education have been used in higher education and leadership training for many years (Aldrich, 2009). Aldrich (2009), defines immersive learning simulations as those simulations that are used in formal programs (i.e., both serious games and educational simulations). Such simulations have traditionally been carried out in the classroom and have been sequential decision-making events with guidelines provided by the instructor; they need to be based on reality, with no predetermined solutions (Hertel & Millis, 2002). Aldrich (2009), gives two examples of immersive simulations in higher education: law students engaging in mock trial simulations to build their skills, and students in business school engaging in simulations such as Eazy's Garage, a case study by Harvard Business Publishing, to learn negotiation skills. Per Aebersold (2016), immersive simulations in higher education focus on assisting students in acquiring discipline-specific knowledge that they can transfer into their specific professional setting. Furthermore, immersive simulations focus on such goals as the transfer of knowledge, skill development, and the application of both knowledge and skill (Aebersold, 2016). These goals are very similar to the goals that are seen in healthcare simulations.

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Simulation Training in Graduate Medical Education

Per Jones et al. (2015), simulation is a technique that replaces and amplifies real experiences. Along these lines, Gaba and DeAnda (1989), state that simulation can evoke and replicate substantial aspects of the real-world in a fully interactive manner. In the medical field, one can find the origins of simulation during Antiquity, when models of human patients were built in clay and stone to demonstrate clinical features of diseases and their effects on humans (Meller, 1997). Later, in the early 1960s, Dr. Peter Safar described the efficacy of mouth-to-mouth cardiopulmonary resuscitation through research on artificial respiration (Cooper & Taqueti, 2008). Encouraged by Safar's research, Ausmund Laerdal, a plastic toy manufacturer, designed a realistic simulator to teach mouth-to-mouth ventilation (Cooper & Taqueti, 2008). Laerdal named the mannequin "Resusci-Anne" (Cooper & Taqueti, 2008). Resusci-Anne enabled physicians to practice hyperextension of the neck and chin lift, two techniques of airway obstruction management that every healthcare professional is required to know and master (Cooper & Taqueti, 2008). Later, Laerdal was advised by Safar to include an internal spring attached to the mannequin's chest wall that permitted the cardiac compression simulation. This was the birth of the most widely used CPR mannequin of the 20th century, "Harvey" (Cooper & Taqueti, 2008; Rosen, 2008).

In 1968, during the American Heart Association Scientific Sessions, Dr. Michael Gordon from the University of Miami Medical School presented Harvey, the Cardiology Patient Simulator (Cooper & Taqueti, 2008). The mannequin could reproduce almost any cardiac disease by varying blood pressure, heart sounds, heart

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murmurs, pulses, and breathing (Cooper & Taqueti, 2008). Due to its efficacy as an education tool, the utilization of Harvey has been applied for training and assessment of trainees in various medical schools, graduate medical training programs, and emergency departments. Moreover, Jones et al. (2015), state that Resusci-Anne and Harvey represent cornerstones of the beginning of modern era medical simulation. After their development, many other types of simulators were created for education and training (Cooper & Taqueti, 2008; Rosen, 2008). Each of them shares a common characteristic: the use of technology to achieve a more effective learning experience.

As technology improved during the 1980s and 1990s, software and computerized systems that could mimic physiologic responses and provide real feedback were produced (Jones et al., 2015). At Stanford University, a group led by Gaba and DeAnda (1988), developed the comprehensive anesthesia simulation environment (CASE). The rationale for the CASE simulator was to incorporate the aviation model of crew resource management for the sake of teamwork training in a realistic environment (Gaba & DeAnda, 1988). Through their research, Gaba and DeAnda (1988), studied whether the CASE simulator could assess technical performance (i.e. placement of instruments or administration of medications), as well as behavioral performance (i.e. the appropriate use of sound crisis management behaviors), including leadership, communication, and distribution of workload to members of the team. Gaba and DeAnda (1988) had 22 subjects (nine first-year residents, nine second-year residents, and four medical students who had completed an anesthesia rotation), undergo simulation sessions that focused on the problem-solving skills of the participants as it related to anesthesia. After each simulator session, the

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subjects were asked to complete a questionnaire concerning the realism of the simulator as well as provide any written comments on the experience. The study results showed that the overall simulation scenario was considered realistic by 17 of the participants. Moreover, one study participant stated that the simulation would be a good teaching tool as it can allow trainees to be exposed to situations that they may not be exposed to in the average ward (Gaba & DeAnda, 1988).

Medical education at all levels is placing an increased reliance on simulation technology to boost the growth of trainee knowledge, provide controlled and safe practice opportunities, and shape the acquisition of trainee's clinical skills (Wayne et al., 2005). Combined with opportunities for controlled, deliberate practice with specific feedback, simulation-based medical training can also promote skill acquisition among medical trainees (Ericsson, 2004; Ewy et al., 1987; Issenberg et al., 2002; Seymour et al., 2002). According to Bandura (1997), gaining proficiency in clinical skills also gives rise to a sense of self-efficacy among medical learners, an affective outcome that accompanies mastery experiences.

A randomized trial study, conducted by Wayne et al. (2005), utilized simulation to address the baseline proficiency of second-year internal medicine residents (n = 38) in Advanced Cardiac Life Support (ACLS) procedures. The researchers reported that the performance of the residents improved significantly after simulator training. Like this study, a randomized control study conducted by Steadman et al. (2006) was conducted to determine the effects of simulation for teaching acute care assessment and management skills. They found that simulation-based learning was superior for fourth-year medical students (n = 34) in the acquisition of these

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skills. Additionally, surveyed participants reported an increase in their clinical competence, while learning without fear of patient harm, and while gaining an increased enthusiasm for the material in a realistic environment (Steadman et al., 2006). Through their study, Steadman et al. (2006) concluded that simulation can provide a trainee with a focused, non-threatening educational environment that is unencumbered by patient service commitment.

Simulation as an Assessment Tool in Medical Education

Simulation has been used as a training tool in medical education since the early 1960s, but has been gradually transitioning to an assessment tool (Devitt, Kurrek, Cohen & Cleave-Hogg, 2001). Simulations involving sophisticated mannequins with heart sounds, respirations, and pulses that respond to a variety of interventions can be used to assess how individuals or teams manage unstable vital signs (Devitt et al., 2001). Epstein (2007), states that surgical simulation centers routinely use high-fidelity computer graphics and hands-on manipulation of surgical instruments to create a multi-sensory environment. Through this innovative technology, simulation is increasingly seen as an important learning aid and may prove to be useful in the assessment of knowledge, clinical reasoning, and teamwork.

In 2000, the ACGME created a toolbox of assessment methods with brief descriptions of each method for graduate medical trainee performance outcomes (Swing & Bashook, 2000). The ACGME toolbox of assessment methods recommends the use of simulation as an instrument to evaluate outcomes that require a trainee to demonstrate or “show how” they are competent to perform various skills (Swing & Bashook, 2000). For example, in the patient care domain, the ACGME lists simulation

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as the “most desirable method” for assessing a medical trainee’s ability to perform medical procedures. Additionally, the ACGME lists simulation as a “next best method” in the assessment of a medical trainee’s ability to develop and carry out patient management plans (Swing & Bashook, 2000). Within the medical knowledge domain, examiners can devise simulations to judge a trainee’s investigative and analytic thinking or knowledge/application of basic sciences (Swing & Bashook, 2000). Per the ACGME toolbox of assessment methods, simulations are a potentially applicable method to evaluate how practitioners analyze their own practice for needed improvements (practice-based learning and improvement) and, in the realm of professionalism, simulations are among the methods listed for assessing ethically sound practice (Swing & Bashook, 2000).

According to Issenberg et al. (1999), the use of simulation technology has an immense potential to shape medical education, certification, licensure, and the quality of patient care delivered. In a case-control study conducted by Wayne et al. (2008), evaluated the effects of simulation training on the quality of the cardiac arrest care provided by residents (n = 78). Study results reported that simulation-trained residents showed significantly higher adherence to American Heart Association (AHA) standards (mean correct responses, 65%; SD = 20%) versus traditionally trained residents with no simulation intervention (mean correct responses, 44%; SD = 20%; p = 0.001). In another study involving 203 second-year medical students at a medical university, the incorporation of Harvey, the cardiology patient simulator, in a required physical skills course, significantly improved overall cardiac examination skills as measured by pretests and posttests results (Woolliscroft, Calhoun, Tenhaken & Judge,

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1987). An additional observation noted that the use of Harvey reduced the time faculty and students would have spent locating enough patients to examine a wide variety of cardiac problems (Woolliscroft et al., 1987). Results from these studies suggest that simulation technology is a reasonable addition to the medical curriculum, as the skills learned on a simulator may be transferable to patient care.

Per Scalese, Obeso, and Issenberg (2007), one of the strengths of simulators for testing purposes is their high degree of reliability. Because of their programming, simulators consistently present evaluation problems in the same manner for every examinee and minimize the variability inherent in actual clinical encounters (Scalese at al., 2007). This reproducibility becomes especially important when high-stakes decisions (e.g., certification and licensure) hinge on these assessments (Scalese et al., 2007). Scalese, Obeso, and Issenberg (2007), state that the use of simulators for such examinations is already occurring in several disciplines. For instance, the Royal College of Physicians and Surgeons of Canada utilize computer-based and mannequin simulations for their national internal medicine certification (oral) exams (Hatala, Kassen, Nishikawa, & Issenberg, 2005), and the American Board of Internal Medicine (2017), employs similar simulations in the clinical skills module that is part of the physician maintenance of certification program.

Assessment of Critical Thinking in GME through Simulation

Per Zayapragassarazan et al. (2016), effective learning involves providing students with a sense of progress and control over their own learning. This requires creating a situation where learners have a chance to try out or test their ideas (Zayapragassarazan et al., 2016). This testing is ideally accomplished by connecting

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students' ideas to concrete experience (Zayapragassarazan & Kumar, 2012; Cooper, 1995). However, Zayapragassarazan et al. (2016), argue that while medical trainees master an enormous body of knowledge, they lack systematic problem-solving abilities and effective clinical decision making. In their conceptual analysis article on critical thinking within medical education, Zayapragassarazan et al. (2016), state that medical professors and practitioners have raised concerns about the low levels of critical thinking cultivated in medical education and stress the need for fostering critical thinking in medical trainees. Per, Zayapragassarazan et al. (2016), healthcare is prone to diagnostic and management errors as reported by the Institute of Medicine in 'To Err is Human' (Kohn et al., 1999). Furthermore, approximately one third of patient problems arise due to diagnostic errors (Kohn et al., 1999). Part of the solution to this issue lies in improving the diagnostic skills and critical thinking abilities of medical trainees as they progress through graduate medical training.

To aid in the fostering of critical thinking skills among graduate medical learners, simulation-based medical education can serve as a starting point for critical thinking and questioning. Ziv, Ben-David, and Ziv (2005), state that simulation-based medical education can create conditions where making mistakes is not harmful or dangerous to patients but is, rather, a powerful learning experience for medical trainees. Error management refers to multiple skills that together comprise a professional approach towards minimizing blunders that specifically characterize the medical system and include all participants in the medical care process (Ziv, Ben-David, & Ziv, 2005). Specific required skills include the medical trainees' awareness of the possibility of imminent mistakes, consciousness of one's competence and

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limitations, recognition of the need to call for help, and strategies to recover from a mistake while minimizing its harmful consequences in patient care (Ziv, Ben-David, & Ziv, 2005).

Although the pedagogic advantages of experiential, situated learning methods within simulation-based medical education are described in a few studies (Dewey, 1994; Tekian, McGuire, & McGaghie, 1999), a limited amount of studies have been conducted that examine the effects of simulation-based training on the critical thinking skills of graduate medical learners. In a qualitative study conducted by Gordon et al. (2001), to understand the responses of medical students to patient simulation, a pilot group of residents ($n = 27$) reported that simulation-based training promoted critical thinking (63%) as it allowed them to build confidence and practice skills in a supportive environment. Additionally, one of the study participants stated, "The simulator puts the student in the 'hot seat' and forces the student to think through emergent problems in a systemic way," while another study participant stated, "Practice through simulation provides medical trainee's with critical situations where they have to think about what to do in order to provide optimal patient care" (Gordon et al., 2001, p. 471).

A more recent study by Daniel-Underwood (2016), examined medical simulation as a method of assessing critical thinking among 12 senior medical students at a university hospital. The study results reported that simulation as an assessment tool provided an environment for the study participants to manage a complex case ensuring patient safety and allowed them to develop their critical thinking skills. Through the utilization of the Association of American Colleges & Universities Value

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Critical Thinking Rubric (2009), modified by Daniel-Underwood (2016), to reflect medical education and the care of a patients, study results stated that participants with weaker knowledge and skills scored below expectations (74%), while participants who grasped concepts from prior knowledge and applied them appropriately to the simulation scenario met expectations, and showed a deeper thinking process important to critical thinking (67%). Through study results, Daniel-Underwood (2016), concluded that simulation can provide a summative assessment of critical thinking in medical trainees by displaying the student's decision-making capacity, as well as their skills, attitudes, and behavior. Furthermore, simulation-based medical education can provide medical trainees with an avenue for self-assessment or reflection that is a powerful tool for growth and improvement of patient care skills (Daniel-Underwood, 2016).

The next section examines the theoretical frameworks utilized within medical education to evaluate critical thinking among trainees while making a connection to the incorporation of simulation-based training as a potential platform to increase critical thinking skills among graduate medical trainees.

Theoretical Framework

This section will review the Five-Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus (1980). This is the current theoretical framework used within graduate medical education to evaluate critical thinking among trainees. Next, this section will review Malcolm Knowles Theory of Andragogy (1968), also known as Adult Learning Theory, as it relates to simulation-based medical education. These two theories formed the lens viewed to conduct this study.

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The theories that were used to define and frame this study stem from cognitive psychology theories and frameworks (Anderson, 2015). Therefore, these theories describe learning through skills development measured through structured or targets of learning (Case, 1974; Inhelder & Piaget, 1958; Skinner, 1938, 1963, 1987). It should be noted there are other current theories that address learning from a distinct perspective. These theories consider the importance surrounding acquisition of language to acquire concepts that allow for critical thinking (Arwood, 1991/2011; Bruner, 1978; Piaget, 1971; Vygotsky; 1962). While these theories can be applied to this research study, they will not be used since at this time graduate medical education defines learning and applications to learning around theories of cognitive psychology (Sullivan, Simpson, Cooney, & Beresin 2013). This is also discussed further in the limitations section and future research section of chapter five.

The Five-Stage Model of Adult Skill Acquisition

The current theoretical framework utilized by the Accreditation Council of Graduate Medical Education (Sullivan et al., 2013) as the basis for competency assessment among graduate medical trainees, is based on the Dreyfus and Dreyfus (1980) five-stage model of adult skill acquisition. Each stage is described with certain attributes (skill, behaviors, and knowledge), and each stage is dependent on completion of the stage before (Dreyfus & Dreyfus, 1980).

The first stage of the five-stage model of adult skill acquisition (Dreyfus & Dreyfus, 1980), is the novice trainee. According to Dreyfus and Dreyfus (1980), novices are learning the process, protocols, procedures, language, and culture of medicine. Their behaviors are rule-governed (learning heuristics) and respond to

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external reward systems (Dreyfus & Dreyfus, 1980). They need supervision and have little or limited problem-solving skills (Dreyfus & Dreyfus, 1980).

The second stage of the five-stage model of adult skill acquisition (Dreyfus & Dreyfus, 1980), is the advanced beginner. These learners recognize common situational aspects in their patient cases that are not apparent apart from the experience (Dreyfus & Dreyfus, 1980). Their behavior is still rule-governed, but their heuristics skills are better developed as is their concept learning (Dreyfus & Dreyfus, 1980). Moreover, medical learners in this stage still require supervision (Dreyfus & Dreyfus, 1980). Per Dreyfus and Dreyfus (1980), based on the description of skills and behaviors, medical students completing their education would possess most of these skills.

The third stage of the five-stage model of adult skill acquisition (Dreyfus & Dreyfus, 1980) is described as competence. According to Dreyfus and Dreyfus (1980), medical learners in this stage see their actions in terms of goals and plans based on some of the important aspects of the situation. Additionally, these medical learners depend on standard procedures as a base of consideration but can modify the plan if necessary (Dreyfus & Dreyfus, 1980). Furthermore, Dreyfus and Dreyfus (1980), state that in this stage, medical learners need supervision and case discussion for problem solving, adding accountability to their actions.

The fourth stage of the five-stage model of adult skill acquisition (Dreyfus & Dreyfus, 1980) is the proficient physician. According to Dreyfus and Dreyfus (1980), medical learners in this stage streamline procedures unconsciously and are proficient in managing conflicting medical situations and in adjusting to the cultural factors.

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Furthermore, Dreyfus and Dreyfus (1980) state that in this stage medical learners need minimal supervision and continue to evolve their critical thinking skills. Per Dreyfus and Dreyfus (1980), all medical learners completing residency should be at this stage.

The fifth and final stage of the five-stage model of adult skill acquisition (Dreyfus & Dreyfus, 1980) is the expert trainee. According to Dreyfus and Dreyfus (1980), at this level in their medical education, expert trainees perform intuitively in synthesizing medical, cultural, and psychological influences into fluid, flexible, and efficient care plans. Additionally, in this stage, medical trainees require no supervision and are self-regulated in their learning (Dreyfus & Dreyfus, 1980). Per Dreyfus and Dreyfus (1980), the expert trainee is considered unconsciously competent.

Per the five-stage model of adult skill acquisition, as the medical trainee develops from the novice (medical student) to the expert (practicing physician), their critical thinking skills are refined to include efficient problem solving, they respond to stimuli that may seem obscure to the less skilled, and perform intuitively in synthesizing medical, cultural, and psychological influences. While the Dreyfus & Dreyfus model is currently accepted in graduate medical education, Peña (2010), argues that model may partially explain the 'acquisition' of some skills (i.e. content knowledge through exposure in patient care). Furthermore, it is debatable if the model can explain the acquisition of clinical skills. The complex nature of clinical-problem solving skills should be taken into consideration when wanting to explain 'acquisition' of clinical skills (Peña, 2010). Additionally, Peña states, "The idea that experts work from intuition, not from reason, should be evaluated carefully" (p. 9).

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Adult Learning Theory and Simulation Training

In 1968, Malcolm Knowles proposed a new label and a new technology of adult learning to distinguish it from pre-adult schooling. Knowles (1968) defined the concept of andragogy as the art and science of helping adults learn, was contrasted with pedagogy, the art and science of helping children learn. Andragogy became a rallying point for those trying to define the field of adult education as separate from other areas of education. Researchers and educators used the term andragogy to distinguish the adult learner from the pedagogical perspective of traditional educational practices (Knowles, 1980, 1984; Merriam, 2001). In 1980, Knowles made four assumptions about the characteristics of adult learners. In 1984, Knowles added the fifth assumption. Table 4 lists Knowles (1984), five assumptions of adult learners.

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Table 4

Knowles' Five Assumptions of Adult Learners

Assumption	Characteristics
Self-Concept	As a person matures his/her self-concept moves from one of being a dependent personality toward one of being a self-directed human being.
Adult Learner Experience	As a person matures he/she accumulates a growing reservoir of experience that becomes an increasing resource for learning.
Readiness to Learn	As a person matures his/her readiness to learn becomes oriented increasingly to the developmental tasks of his/her social roles.
Orientation to Learning	As a person matures his/her time perspective changes from one of postponed application of knowledge to immediacy of application. As a result, his/her orientation toward learning shifts from one of subject- centeredness to one of problem centeredness.
Motivation to Learn	As a person matures the motivation to learn is internal.

Knowles, 1984a

In addition to the five assumptions of the adult learner, Knowles (1984b), suggested four principles that should be applied to adult learning: (1) adults need to be involved in the planning and evaluation of their instruction; (2) experience (including mistakes) provides the basis for the learning activity; (3) adults are most interested in learning subjects that have immediate relevance and impact to their job or personal life; and (4) adult learning is problem-centered rather than content-oriented.

The 1970s and early 1980s witnessed much writing, debate, and discussion about the validity of andragogy as a theory of adult learning (Merriam, 2001). Hartree (1984), questioned whether there was a theory at all, suggesting that perhaps these were just principles of good practice, or descriptions of "what the adult learner should

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be like" (p. 205). Knowles (1984), himself came to concur that andragogy is less a theory of adult learning than a model of assumptions about learning or a conceptual framework that serves as a basis for an emergent theory.

The second area of criticism focused on the extent that the assumptions are characteristic of adult learners only. Critics argued that some adults are highly dependent on a teacher for structure, while some children are independent, self-directed learners (Merriam, 2001). Per Merriam, Mott, and Lee (1996), certain life experiences can act as barriers to learning. Further, children in certain situations may have a range of experiences qualitatively richer than some adults (Hanson, 1996). In 1980, Knowles moved from an andragogy versus pedagogy position to representing them on a continuum ranging from teacher-directed to student-directed learning. This acknowledgment by Knowles (1980), resulted in andragogy being defined more by the learning situation than by the leaner.

Within the parameters of adult learning theory, Jones et al. (2015), state that the spectrum from pedagogy to andragogy is a continuum that manifests itself according to the learning situation. Furthermore, Jones et al. (2015), state that there are aspects of intrinsic and extrinsic motivation and reflection that play a significant role in medical education that are not classically addressed by andragogy, but through the adoption of a student-directed model. Simulation can play a central role in a student-directed learning model by providing medical trainees with a safe learning environment, where they can learn from their mistakes, through complex procedural and clinical problem solving (Jones et al., 2015). Per Konetes (2010), certain uses of educational simulations lend themselves more to fostering internal motivation,

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optional, and tangential applications, while many forms of direct content delivery for courses or units rely on extrinsic factors for completion and success. Motivation also characterizes the learner's intrinsic and extrinsic reasons for participating in and becoming engaged with the content of an educational simulation (Konetes, 2010).

Through a neuroscience lens, this level of engagement is associated with the neuromodulator dopamine (DA), that has long been recognized to play a fundamental role in motivational control and reinforcement learning processes (Mirolli, Santucci, & Baldassarre, 2013). Specifically, single neuron recordings demonstrate that most dopamine neurons are activated by the rewarding characteristics of somatosensory (part of the sensory nervous system), visual, and auditory stimuli (Mirolli et al., 2013). Cognitive processing during a simulation can potentially enhance plasticity by boosting dopamine to benefit learning and memory, allowing long-term consolidation to take place within the hippocampus (Düel et al., 2010). Per Jones et al. (2015), successful simulations can create an intrinsic desire within the medical trainee to participate in and accomplish the tasks given to fully engage the trainee and maximize the educational potential of the exercise.

According to Jones et al. (2015), simulation-based medical education can help create a clear "need to know," since it mimics real life situations and gives medical trainees the chance to practice procedures – both within the safety of a controlled environment and the possibility to determine in advance the nature of the cases to be addressed. Thus, it becomes possible to cover, in an ordered manner, the most important diseases (namely, the most prevalent and acute conditions that may require immediate interventions), overcoming the expected variability of real scenarios in a

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hospital setting (Jones et al., 2015). Figure 3, created by Jones et al. (2015), lists the characteristics of the adult learning process as it relates to simulation-based medical education. Understanding how the simulation experience affects future practice is a crucial step to improve performance (Jones et al., 2015).

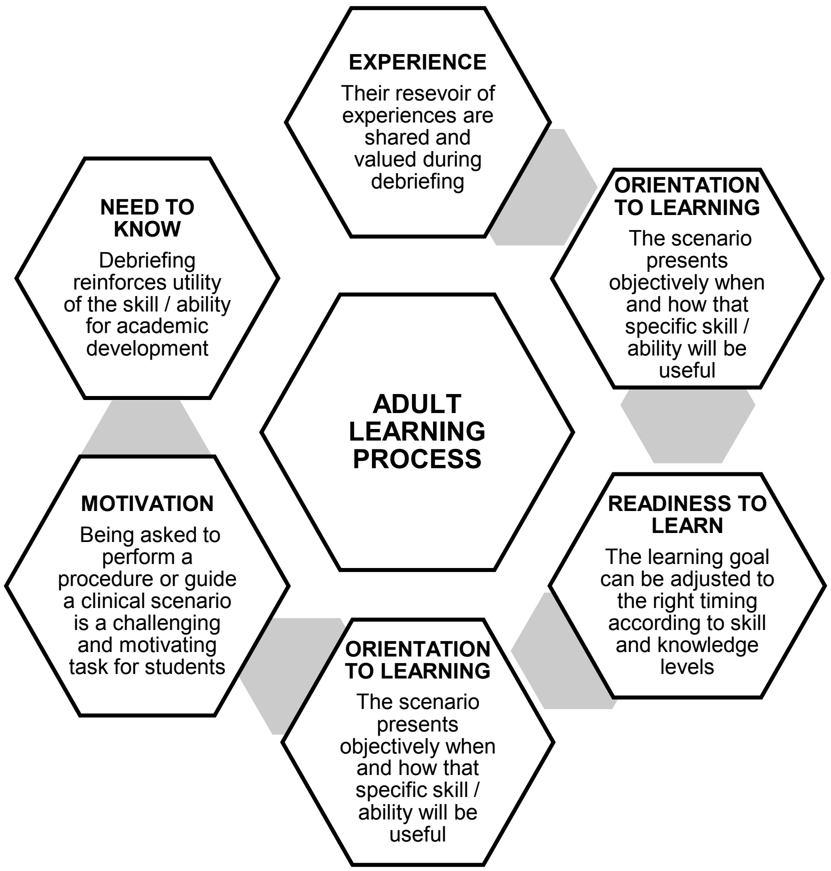

Figure 3. Characteristics of the adults learning process within simulation training by Jones et al. (2015).

Summary

Graduate medical education integrates knowledge, skills, behaviors, and attitudes in developing students' ability to care for patients. Moreover, assessment is a fundamental process to assure that learning has occurred and is key in determining

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gaps in knowledge as the trainee progresses from a novice to expert (Dreyfus & Dreyfus, 1980). Simulation-based training can evaluate knowledge, competence in procedural skills, communication, and immerse the trainee in a realistic environment (Knowles, 1980). However, failure to recognize lapse in knowledge or skill can lead to potentially fatal errors for patients. Simulation-based training may be one of the better tools to determine a medical education trainee's ability to integrate knowledge and expertise to solve patient problems and achieve safe and effective patient care through the development of critical thinking. Figure 4 describes how critical thinking in simulation-based education training within graduate medical education was extracted from The Five-Stage Model of Adult Skill Acquisition (Dreyfus & Dreyfus, 1980) and the Adult Learning Theory (Knowles. 1980).

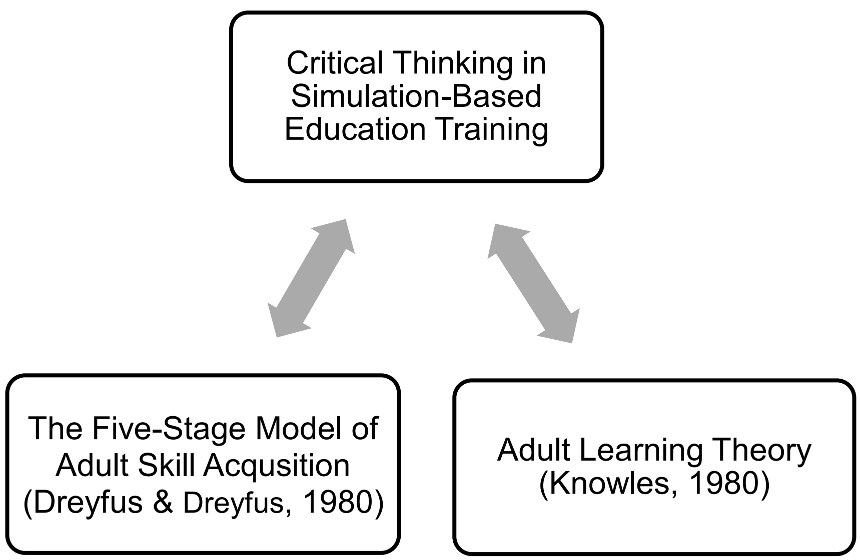

Figure 4. Critical thinking in simulation-based education training within graduate medical education.

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As examined through the research thus far, the analysis of how learning takes place within the simulation-based environment, specifically, the integration of critical thinking skills within this setting, remains to be explored. In this study, the researcher aimed to investigate the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees through the utilization of a pre-and posttest, the AAC&U VALUE Critical Thinking Rubric (2009), and through individual interviews with trainees after the simulation. The goal of this study was to understand the potential of simulation-based training as a tool to improve medical competencies among trainees in a cardiovascular graduate medical training program. Chapter Three provides an explanation of the methods and materials utilized in this study to analyze the critical thinking skills of the graduate medical trainees that participated in the study.

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Chapter Three: Research Design and Methodology

This chapter describes the methods of data collection and analysis related to the research problem and purpose of the study. This chapter also includes an examination of the research questions, hypothesis, and rationale for completing this study. In addition, details pertaining to the role of the researcher, participants and setting, and ethical considerations for the study are also provided in this chapter.

Re-Statement of Purpose and Research Questions

The purpose of this study was to investigate the effects of simulation-based training experiences on the critical thinking skills of 10 graduate medical education trainees. To examine the effects of simulation-based training experiences on the critical thinking skills of 10 graduate medical education trainees, three research questions guided this study:

1. How do the participant's rate on critical thinking skills on the AAC&U Critical Thinking VALUE Rubric (2009), as revealed by their actions during a simulation?
2. What is the effect of simulation-based training on participants' critical thinking skills?
    a. As revealed through participant pre/posttest scores?
    b. As revealed through interviews with participants regarding their perspective on a simulation experience?
3. After the simulation, how do participants describe the impact of participating in a simulation-based training on their clinical practice?

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The goal of this study was to understand the potential of simulation-based training as an innovative tool to improve medical competencies among trainees in a graduate medical training program.

Role of the Researcher

Within the researcher's professional and personal endeavors, education has always been at the forefront. The researcher received their bachelors in elementary education as well as their master's in education, with a concertation in post-secondary and higher education. The researcher's doctoral program is also in education with a concentration in neuroeducation. Most of the researcher's experience in the classroom ranges from kindergarten to fourth/fifth, dual-language, as an intern and student teacher. While the researcher found a great passion in primary education, opportunities in higher education as a student worker allowed the researcher to cultivate an affinity for adult learning. The researcher's professional roles in post-secondary education have allowed the researcher to work in a range of departments within higher education institutions; from a top tier executive MBA program, to a prominent law school, and now, a nationally recognized medical subspecialty training program. In each position, the researcher has received a comprehensive understanding of program management and student support, while promoting an educational culture that is inclusive to all learners. These positions have also provided the researcher with an understanding of the importance in developing an innovative learning platform that fosters growth within the adult learner.

Currently, the researcher is the Educational Manager of a medical training program within a university hospital in the Pacific Northwest region of the U.S. This

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position oversees seven ACGME accredited medical fellowship training programs, as well as creates continuing medical education (CME) opportunities for medical staff (faculty, fellows, nurses), through the establishment of regional medical conferences. The researcher has been in this role for two years within the university hospital and has received professional development training in program management through the Accreditation Council for Graduate Medical Education. In this role, the researcher has also received opportunities to collaborate with the teaching and learning center at the university hospital and aided in the establishment of a faculty coach mentoring program for medical students. This program provides coaching tips and tricks for current medical faculty who serve as advisors for early medical students.

One of the more critical duties of the researcher as an education manager involves the organization and implementation of bi-annual clinical competency committee meetings that are a requirement of all accredited ACGME medical fellowship training programs. A Clinical Competency Committee (CCC), as defined by the ACGME is, "A required body comprising three or more members of the active teaching faculty, who serve as advisories to the Program Director, and reviews the progress of all medical trainees in the program" (ACGME Glossary of Terms, 2013, p. 2). The CCC is comprised of 10 core faculty of the fellowship program who have a significant role in the education of the medical trainees and who have documented qualifications to instruct and supervise these trainees (ACGME Glossary of Terms, 2013). Core faculty devote at least 15 hours per week to medical trainee education and administration. All core faculty evaluate the competency domains, work closely with,

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and support the Program Director, assist in developing and implementing evaluation systems, and teach and advise medical trainees (ACGME Glossary of Terms, 2013).

During each CCC meeting, core faculty evaluate the performance of each medical trainee through the utilization of formative and summative evaluation. Formative evaluation is the assessment of a medical trainee with the primary purpose of providing feedback for improvement as well as to reinforce skills and behaviors that meet established criteria and standards without passing a judgment in the form of a permanently recorded grade or score (ACGME Glossary of Terms, 2013). Summative evaluation is assessment with the primary purpose of establishing whether performance measured at a single defined point in time meets established performance standards, permanently recorded in the form of grade or score (ACGME Glossary of Terms, 2013). Formative and summative evaluations of medical trainees is collected every four weeks through the evaluation of a trainee's procedural and clinical performance in the clinical setting as it relates to the six core competencies (patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice).

In these meetings, the researcher has observed concerns from committee members regarding the general fund of knowledge for some of the program trainees. Specifically, these concerns center on a potential lack of clinical thinking skills when trainees are presented with cases that are not "textbook" or easy to address. Additionally, the researcher has noticed in these meetings that a trainee's gaps in fund of knowledge or inability to think quickly during messy situations has caused much discussion amongst committee members regarding how to address these concerns

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prior to a trainee's completion date. While interventions such as more clinical time or in-depth reading have been recommended by the CCC to address trainee gaps in knowledge, simulation training has not been explored with this group until the most recent CCC meeting on May 4, 2017.

Through the analyzation of CCC member comments and informal medical trainee discussion, the Program Director and the researcher sought the utilization of simulation-based training to address these issues as a two-prong approach. The two aims of the simulation-based training were to adhere to the ACGME requirement of incorporating simulation in graduate medical training and to determine if simulation could increase critical thinking skills among medical trainees through didactic training. These factors are what led the researcher to establish this research study. Through this study, the researcher aimed to explore the use of simulation as a tool to address critical thinking among medical trainees. In addition, the researcher aimed to provide the medical training program with another educational method that could potentially address the gaps in a trainee's fund of knowledge and better prepare them for physician roles post training.

Mixed Methods Design

This methodological study used a mixed-methods research design. Johnson and Onwuegbuzie (2004), describe mixed-methods research as, "The class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p. 17). This study was compromised of a simulation-based education training session that analyzed the effects of a hemodynamics of cardiogenic shock simulation-based

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training experiences on the critical thinking skills of 10 graduate medical education trainees, specifically fellows, through the utilization of a pre-and posttest, the AAC&U VALUE Critical Thinking Rubric (2009), and post-simulation interviews with the study participants. The reason for conducting this mixed-methods research was an attempt to strengthen the use of multiple approaches in answering the research questions (Johnson & Onwuegbuzie, 2004).

Per Brewer and Hunter (1989), researchers should collect multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses. The quantitative techniques that were utilized in this study included a one group pre/posttest design as well as a one group critical thinking rubric design (AAC&U VALUE Critical Thinking Rubric, 2009). These techniques followed a pre-experimental design as a single group (10 graduate medical education trainees), with no comparison group. As stated by Sackett and Paul (1993), like all experimental designs, the goal is to determine if the treatment had any effect on the outcome. Furthermore, without a comparison group, it is impossible to determine if the outcome scores are any higher than they would have been without treatment (Sackett & Paul, 1993). Through the incorporation of a pre/posttest and critical thinking rubric, the researcher wanted to examine if there was a difference in the scoring of participants' critical thinking skills when comparing the critical thinking rubric and pre/posttest results.

The qualitative technique that was utilized for this study was comprised of post-simulation interviews. Per Holstein and Gubrium (2003), qualitative interviews

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provide a way of generating empirical data about the social world by asking people to talk about their lives. For this study, the researcher felt that it was important to incorporate the perspectives of each study participant in an effort to capture personal narratives surrounding the use of simulation in a medical training program. Furthermore, the researcher wanted to make a connection between the quantitative and qualitative data that went beyond scores, in an effort to understand how the study participants perceived the utilization of simulation as a method to refine their clinical and procedural competencies. Through post-simulation interviews, the researcher examined the prior experience that participants had with simulation training and how they viewed the incorporation of simulation in graduate medical training programs. Additionally, the researcher evaluated in what ways, if any, the participants believed the simulation training had an impact on their clinical practice.

By applying quantitative (pre/posttest, critical thinking rubric), and qualitative (post-interviews) techniques, the researcher aimed to address the questions posed in this research study. Table 5 provides a summary regarding the research methods that were utilized for this study and the rationale for each.

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Table 5

Research Methods and Rationale

Research Question	Data Collected to Answer	Data Analysis Technique(s)
1. How do the participants rate on critical thinking skills on the AAC&U Critical Thinking VALUE Rubric (2009) as revealed by their actions during a simulation?	AAC&U Critical Thinking VALUE Rubric (2009)	Frequency counts of the percent of the participants at each level (i.e. benchmark, milestones, capstone) on each dimension (i.e. explanation of issues, evidence, influence of context and assumptions, student's position, conclusions and related outcomes) Rationale: to analyze the critical thinking skills of 10 graduate medical education trainees as scored by the AAC&U Critical Thinking VALUE Rubric (2009)
2. What is the effect of a simulation- based training on participants critical thinking skills? 2a. As revealed through participant pre/posttest scores? 2b. As revealed through interviews with participants regarding their perspective on the simulation experience?	Pre/posttest and post-simulation interviews	Paired sample *t*-test and thematic coading using grounded theory Rationale: to analyze study participants pre-and post-test scores through paired sample *t*-tests to evaluate the participants fund of fund of hemodynamic of cardiogenic shock knowledge before and after the simulation session
3. How do participants describe the impact of participating in a simulation-based training on their practice?	Post-simulation Interviews	Pattern coding Rationale: to determine if the participants believe that a simulation training has any impact on their critical thinking within their clinic practice

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Participants and Setting

With the help of the Program Director of the cardiovascular fellowship program, a criterion sampling of 10 graduate medical education trainees was obtained. Creswell (2013), describes criterion sampling as "all cases that meet some criterion" (p. 119). Additionally, Schatzman and Strauss (1973), state the researcher selects people consistent to the purpose of the study. The criterion in this case was that all participants were graduate medical education trainees as defined by the ACGME as "a physician in a program of graduate medical education accredited by the ACGME who has completed the requirements for eligibility for first board certification in the specialty" (ACGME Glossary of Terms, 2013, p. 5). An email was sent to all 15 graduate medical trainees informing them of the purpose of the study, the voluntary nature of their participation in the study, and their ability to withdraw their consent at any time without penalty. 11 trainees responded to the email, agreeing to participate in the study, and approved consent. Four trainees declined to participate in the study; three of the trainees received permission to attend an educational conference during the week of the simulation and one trainee had a vacation scheduled during the day of the simulation. Further, one trainee who agreed to participate in the study was not present during the time of the simulation. This resulted in a total of 10 study participants.

To protect the privacy of the study participants, each trainee was given letter. Participants A, B, and C were third-year cardiovascular medicine trainees. Participants D and E were second-year cardiovascular medicine trainees. Participants F, G, H, I, and J were first-year cardiovascular trainees who began their fellowship training one

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month prior to the study simulation session. There were five male participants; three were first-year trainees and two were second-year trainees. There were five female participants; two were first-year trainees and three were third-year trainees. The mean age of the study participants was 31. Table 6 provides a participant description summary.

Table 6

Simulation Participant Description Summary

Participant name	Identification	Post-graduate year	Training year
Participant A	Female	6	3
Participant B	Female	6	3
Participant C	Female	6	3
Participant D	Male	5	2
Participant E	Male	5	2
Participant F	Female	4	1
Participant G	Female	4	1
Participant H	Male	4	1
Participant I	Male	4	1
Participant J	Male	4	1

The setting for the study occurred at a university hospital simulation center within the Pacific Northwest region of the United States. The fellowship program is an ACGME accredited program at the university hospital. Program accreditation is defined by the ACGME as "a voluntary process of evaluation and review based on published standards and following a prescribed process, performed by a non-governmental agency of peers" (ACGME Glossary of Terms, 2013, p. 2). The

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university hospital educates health professionals and scientists and provides patient care, community service and biomedical research. It educates about 4,500 students and trainees. Of those students and trainees, about 1,100 are interns, residents, and postdoctoral fellows. There are over 50 residency and fellowship programs at this university hospital. The university hospital simulation center is a 27,000-square foot facility that houses multi-purpose classrooms, debriefing rooms, bed skills training labs, and simulation suites. Audio and video systems in each room can capture simulations and other learning activities.

Ethical Considerations

Institutional Review Board (IRB) approval was provided by both the Pacific Northwest University Hospital and University of Portland. The Program Director initially contacted study participants to request participation in the case-based simulation at least one month prior to the session date. Once the participants expressed interest, the researcher contacted the participants to obtain consent for the study through a consent form (see Appendix A). Participants were then informed of the purpose of the study via email, the voluntary nature of their participation in the study, and were reassured that their participation or lack of participation and their scores on the rubrics would in no way affect their performance in their progression within the training program.

The Program Director and the researcher also explained to participants that while their faces may be recognized in the digital recordings, participant names would not be associated with study results. In addition, confidentiality was respected for all willing participants. The participants were informed via email that the study might

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cause the same discomfort participants may normally feel when they are recorded in curriculum-planned simulation activities. Participants were given the opportunity to ask questions regarding the study and simulation via email, phone or in person. Three of the 10 study participants had concerns regarding whether their names would be included in the study results. The researcher assured the three study participants via email, as well as the rest of the study participants, that IRB protocol does not permit for the release of study participant names. Consent forms from trainees who agreed to participate in the study were scanned and stored electronically within the Pacific Northwest University Hospital secure server on the researcher's password protected computer (university hospital property). Results from the pre-and post-test, paper and pencil scored critical thinking rubrics, and digital recordings (video and audio), were also saved within the university hospitals secure server on the researcher's password protected computer (university hospital property). The only individuals who had access to the study data were those directly involved in the research including the Program Director.

Design and Procedures

The following procedures were taken during this study. The Program Director initially contacted the fellowship trainees to request participation in the simulation one month prior to the session date. Once a trainee agreed to participate in the study and signed the consent form (Appendix A), she or he received the case-based simulation pretest one week prior to the simulation date. The pretest was delivered to the participants electronically via SurveyMonkey. Next, on the day of the simulation, one hour prior to the simulation time, the participants received a conference lecture based

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on the cardiovascular content area being addressed within the case-based simulation session. The Rotation Director of the cardiovascular intensive care unit conducted the conference lecture. A Rotation Director, as defined by the ACGME Glossary of Terms (2013), oversees the educational content of the trainees' assigned rotation (i.e. cardiovascular intensive care unit or CVICU), and insures that trainees are adhering to the goals and objects defined for their given rotation The Rotation Director is an attending physician, specializing in cardiovascular critical care, and has been in his or her respective position for five years at the study site school. This conference lecture was part of the mandatory didactic training within the graduate medical training program and was not a part of this study. Didactic training, as defined by the ACGME is, "a kind of systematic instruction by means of planned learning experiences, such as conferences or grand rounds" (ACGME Glossary of Terms, 2013, p. 4).

Immediately after the conference lecture, participants arrived at the simulation center where they were briefed on the equipment, expectations, and flow of the study. Participants were placed in homogeneous groups based on their post-graduate training year (PGY level). Through this group makeup, there were three total participant groups as there are only three PGY levels represented within a typical ACGME accredited graduate medical training program. All three groups had an hour to run through the simulation session as allotted by the simulation center per their restrictions in the timeframe booked for the simulation session. The simulations began with a basic verbal description of the patient clinical scenario by the CVICU Rotation Director, including pertinent medical history and events. Once the participants entered the simulation suite, the scenario began, with the simulation mannequin programmed

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with hemodynamics of cardiogenic shock, vital signs, and physical exam findings consistent with a clinical decompensation event following an acute myocardial infraction.

The cognitive level of the case is defined by the American College of Cardiology (ACC) Core Cardiology Training Symposium (COCATS) that provides curriculum recommendations for cardiovascular graduate medical training programs that cover overall training in clinical cardiology and specialized areas of cardiovascular medicine (Halperin, Williams, & Fuster, 2015). The COCATS outline training recommendations on hemodynamic stress and cardiac arrest that cardiovascular medical trainees must show competency in, as defined by the ACC, within each PGY of the program (Halperin et al., 2015). This recommendation was utilized within the simulation, as well as the pre/posttest, to assess core competency components and milestones for each PGY level represented by the participants of the study (Halperin et al., 2015).

Within the simulation setting, the study participants had access to emergency resuscitation equipment, echocardiograms, electrocardiograms, emergency medications, transvenous pacing catheters, pulmonary artery catheters, and laboratory support. During the simulation, study participants were expected to assess the changes in hemodynamic stability of a high-fidelity patient mannequin, provide differential diagnoses, interpret the etiology of the decompensation, and utilize appropriate patient care management strategies. Each simulation session (three in total per represented PGY levels) were videotaped and evaluated by three raters through the utilization of the AAC&U Critical Thinking VALUE Rubric (2009). Information on the raters and

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inter-rater reliability is addressed in the data analysis section of this chapter. The researcher also reviewed each of the videotaped simulation sessions to assess the quality of the video (i.e. trainee actions are visible, and audio is clear). The researcher did not evaluate the participants during the simulation due to not having the medical knowledge needed to assess hemodynamic shock. After the completion of the simulation session, participant groups transitioned to the simulation debrief. The simulation debrief was not reviewed during this study but may be reviewed by the researcher in another study at a later time.

One week after the simulation session, the study participants received a case-based simulation posttest that was the same as the pretest provided. The one-week posttest timeframe was chosen to adhere to the Program Directors request in allowing the study participants to have time after the simulation session to resume their clinical duties. The posttest was delivered to the study participants electronically via SurveyMonkey. Two weeks after the simulation session, the researcher requested an interview with all 10 study participants. The researcher chose the two-week interview timeframe to allow the study participants time to reflect on the simulation, as well as their critical thinking skills, as they resumed their clinical duties. Participants B, C, D, E, G, H, and J responded, agreeing to participate in the interview. Participant F responded and stated that she would prefer not to interview since she arrived at the simulation 10 minutes before the session ended and felt that she could not provide any direct insight. Participant A and Participant I did not respond after numerous emails and phone calls and were therefore not included in the interview responses. The

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researcher conducted an interview, individually, with seven of the 10 study participants in a conference room and asked the following questions:

1. What has been your experience with simulation in graduate medical education prior to this simulation session?
2. How has this simulation session affected you, positively or negatively?
3. Overall, do you feel that simulation training can have any impact on your clinical judgment in the clinical setting? – Please explain
4. To what extent has participating in this simulation experience impacted your practice? – Please provide an example

The researcher then audio recorded and transcribed each participant response to the interview questions.

Sources of Data

Three sources of data were obtained during this study. They were a pre-and posttest, a videotaped simulation session, and audio recorded post-simulation interviews.

Pre-and post-test. As noted by Dugard and Todman (1995), pre-test-post-test control group designs are well suited to investigating effects of educational innovations and are common in educational research. To study the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical trainees, study participants completed a pretest one week before the hemodynamics of cardiogenic shock simulation session and a posttest one week after the simulation session. The pre-and posttest provided a clinical scenario that required participants to determine 'correct' next steps in identifying and managing a patient in

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hemodynamic shock through five total questions. Three of the questions on the pre- and posttest were multiple choice and resulted in one 'correct' next step as it related to the clinical scenario. These questions were one point each for a total of three points. The last two questions on the exam were written response and required that participant's state the interventions needed to address the clinical scenario given in each question. Points assigned to the participants' responses on these two questions were based on their level of critical thinking, specifically distinguishing between a rote response and one that required higher level thinking (Rotation Director, personal communication, 2017). The total amount of points a participant could receive on the pre-and posttest was thirteen. The pre/posttest and scoring rubric are provided in Appendix B.

The pre/posttest was created by the CVICU Rotation Director as a method to assess the graduate medical trainees' fund of knowledge, as it related to the study simulation scenario that involved the management of cardiogenic shock based on hemodynamics. As discussed in the study design, the cognitive level of the pre/posttest was defined by the American College of Cardiology (ACC) Core Cardiology Training Symposium (COCATS), to provide curriculum recommendations for cardiovascular fellowship programs that cover overall training in clinical cardiology and specialized areas of cardiovascular medicine (Halperin et al., 2015). These recommendations were utilized within the pre/posttest to assess core competency components and milestones for each PGY level represented by the participants of the study (Halperin et al., 2015). Credentials regarding the CVICU Rotation Director's professional background are addressed in the design and

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procedures section of this chapter. The goal of the pre-and post-test was to provide each study participants' fund of knowledge as it related to their hemodynamic critical thinking skills changes before and after the simulation.

To strengthen the construct validity of the pre/posttest, the researcher provided the exam to three recently completed (graduated June 2017) cardiovascular trainees, two weeks prior to distribution of the pretest to study participants, to determine if modifications were needed to the exam. Table 7 displays the mean score and standard deviation of all three fellows on the exam. A one sample *t*-test reported a statistically significant mean score of 11.33 for all three completed trainees on the exam, conveying a high fund of hemodynamic knowledge. The trainees did not provide any comments or recommendations for modifications to the exam. Per the pilot exam results, the researcher provided the pretest to the study participants with no modifications.

Table 7

Completed Cardiovascular Trainees Pilot Pre/Posttest Scores

Trainee Group	*M*	*SD*
AY 2017 Graduated Cardiology Fellows	11.33	1.26

Note. $n = 3$, $*p < .001$

Videotape simulation session. Each of the three simulation sessions were videotaped so information important to each session could be reviewed and evaluated by the three raters using the AAC&U VALUE Critical Thinking Rubric (2009). This assured that key information from each session was noted appropriately. This also allowed for the recording of nonverbal communication such as body language and

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procedural techniques. Each session was an hour in length per the time allocated to each PGY group to run through the simulation. This timeframe was selected to adhere to the reserved time in the simulation lab, while allowing each group to run through the simulation in a consistent period of time.

Audio recorded interviews. All seven post-simulation interview sessions were audio-recorded using a recording device. All 10 study participants were individually invited to provide their thoughts regarding the simulation session as well as the impact that the simulation session had in their clinical practice. Seven of the 10 study participants provided a post-simulation interview. As stated by Dörnyei (2007), qualitative data are 'most often' collected by researchers through interviews and questionnaires. However, interviews compared to questionnaires are most powerful in eliciting narrative data that allows researchers to investigate people's views in greater depth (Kvale, 2006). Each interview was transcribed and coded using a grounded theory coding method by Auerbach and Silverstein (2003), to create thematic categories. This coding method is a procedure for organizing the text of the transcripts and discovering repeating ideas within the narratives (Auerbach & Silverstein, 2003). Per Auerbach and Silverstein (2003), you then develop your thematic categories from these repeating ideas.

Data Analysis

Data collected for this study was analyzed using a mixed-methods approach. Per Sechrest and Sidani (1995), growth in the mixed-method movement has the potential to reduce some of the problems associated with singular methods. Furthermore, by utilizing quantitative and qualitative techniques within the same

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framework, mixed-methods research can incorporate the strengths of both methodologies (Johnson & Onwuegbuzie, 2004). The data analysis methods are described as it pertains to each research question.

The first research question asked: *How do the participant's rate on critical thinking skills on the AAC&U Critical Thinking VALUE Rubric (2009), as revealed by their actions during a simulation?*

To address this question, the AAC&U Critical Thinking VALUE Rubric (2009) was used during the study to rate participants on their critical thinking skills as revealed by their actions in relation to the management of a patient with cardiogenic shock based on hemodynamics during the simulation. The Association of American Colleges and Universities (AAC&U) states that the Critical Thinking VALUE Rubric (2009) was developed by teams of faculty experts representing colleges and universities across the United States through a process that examined many existing campus rubrics and related documents for each learning outcome and incorporated additional feedback from faculty. The AAC&U Critical Thinking VALUE Rubric (2009) was established to evaluate and discuss student learning at all undergraduate levels within a basic framework of expectations such that evidence of learning can be shared nationally through a common dialog and understanding of student success. To determine how the study participants rated on the AAC&U Critical Thinking VALUE Rubric (2009), as revealed by their actions during the hemodynamics of cardiogenic shock simulation session, the researcher conducted frequency counts of the percent of the participants at each level (i.e. benchmark, milestones, capstone), on each dimension (i.e. explanation of issues, evidence, influence of context and assumptions,

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student's position, conclusions and related outcomes), to determine each participant's critical thinking level as defined by the AAC&U Critical Thinking VALUE Rubric (2009). The AAC&U Critical Thinking Rubric (2009), is outlined in Appendix C. The researcher then calculated the mean of the overall score of participants' critical thinking scores on the rubric.

The raters the researcher selected for the AAC&U Critical Thinking Rubric (2009) were two cardiovascular faculty physicians and one nurse practitioner. The criteria that the researcher utilized for selecting raters was based on the following (Doolen, 2015): (a) each had experience in the case-based content selected for the simulation; (b) each is currently engaged in simulation-based training; and (c) each has at least two years of simulation-based training in graduate medical education. In addition, the three medical personnel the researcher selected as raters for this study have a component of graduate medical educator within their roles. Credentials for the CVICU Rotation Director have been provided in the study design section of this chapter. The second faculty physician is the cardiovascular fellowship Program Director. The Program Director has been in her respective role for two years and has been a cardiovascular physician for more than 10 years. The Nurse Practitioner is the lead nurse in the heart failure ward within the cardiovascular department. The Nurse Practitioner has been in her respective role for five years. Table 8 outlines the credentials pertaining to the three raters for this study.

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Table 8

Credentials of the Critical Thinking Rubric Raters

Professional Title	Prior and Current Professional Experience
Cardiology Program Director	Has been in her current role for two years and has been a cardiovascular physician for more than 10 years.
Cardiology Nurse Practitioner	Has been in her current role for five years and has prior experience teaching nursing students in the simulation lab.
Cardiology ICU Rotation Director	Is an attending physician, specializing in cardiovascular critical care, and has been in his current role for five years.

To strengthen inter-rater agreement, the researcher provided a brief training workshop with all three raters, two weeks prior to the simulation session. The goal of this training workshop was to provide a simulation analysis and collect agreements from each rater as a method to reduce observer error and enhance the reliability of the scoring of study participants using the AAC&U Critical Thinking Rubric (2009). The researcher scheduled a 30-minute meeting with the three raters in a conference room and provided them with a print out of the AAC&U Critical Thinking Rubric (2009). Since this was the first time all three raters were exposed to the AAC&U Critical Thinking Rubric (2009), the researcher reviewed the components of the critical thinking rubric with the raters and answered any questions they had regarding the instrument. Next, the researcher played a 13-minute, mock code training video (Beach, 2015), via YouTube, and had the raters take notes on the three learners in the video regarding how the trainees in the video identified and managed a code blue. A code

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blue is an emergency situation where a patient is in cardiopulmonary arrest requiring a team of providers (sometimes called a 'code team') to rush to the specific location and begin immediate resuscitative efforts (Villamaria, et al., 2008).

After the video ended, the researcher had each rater grade all three trainees in the video separately using the AAC&U Critical Thinking Rubric (2009). After each rater completed his or her grading of the trainees in the video, a group discussion was held to review all three rater scores and discuss any areas of the rubric that may have been difficult to understand. All three raters stated that the rubric was fairly straight forward and did not have any questions regarding the scale or format of the rubric. In haste to finish the pilot testing and allow the raters to return to their clinical duties, the researcher left the graded rubrics in the conference room. The researcher then returned to the conference room two hours later and found that the rubrics were no longer there. As a result, the researcher was unable to run a frequency score of the rubric scores and determine inter-rater agreement for the pilot training. The researcher spoke with their research chair about this error and determined that this was a limitation in the data results.

A study conducted by Gleason et al. (2013), incorporating the AAC&U Critical Thinking Rubric (2009) to determine critical thinking abilities among pharmacology students, used a similar attempt to strengthen inter-rater agreement. Gleason et al. (2013) provided raters with training on using the rubric and had them participate in a calibration process. During the calibration process, the rubric was reviewed and discussed by the raters and the researchers to resolve assessment discrepancies and reduce inter-assessor variability. Results pertaining to inter-rater

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reliability scores were not reported in Gleason et al. (2013) study results. A more recent study by Daniel-Underwood (2016), incorporating the AAC&U Critical Thinking Rubric (2009) to test medical simulation as a method of assessing critical thinking among senior medical students, used a pilot study to determine inter-rater reliability and make modifications to the rubric. The pilot testing initially showed the interpretation of participant skill level between raters was an issue (Daniel-Underwood, 2016). To address this, Daniel-Underwood (2016) reviewed and discussed the scores with the raters (type of discussion not disclosed in study), and a consensus was reached. After running another pilot study, Daniel-Underwood (2016) calculated a Kappa score of 0.64, showing good agreement among the raters.

The second research question asked: *What is the effect of a simulation-based training on participant's critical thinking skills?*

2a. As revealed through participant pre/posttest scores?

2b. As revealed through interviews with participants regarding their perspective on a simulation experience?

To address research question 2a, the researcher analyzed study participants' pre-and post-test scores through a paired sample *t*-test to evaluate the participant's growth in hemodynamic knowledge before and after the simulation session. According to Mee and Chua (1991), a paired sample *t*-test, sometimes called the dependent sample *t*-test, is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. In a paired sample *t*-test, each subject or entity is measured twice, resulting in pairs of observations (Mee & Chua, 1991). As discussed in the sources of data section of this chapter, the pre/posttest were the same

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to observe measurements in data. The Rotation Director graded all exams and provided the scores for each study participant. Participant names were omitted from the exams when provided to the rotation director to lessen any potential grading bias. The researcher then utilized a paired sample *t*-test to analyze the pre/posttest completed by the 10 study participants to compare overall growth in scores.

To address research question 2b, the researcher utilized the post-simulation interview session to analyze participant responses pertaining to their perspective on the simulation experience. Participant responses were audio recorded (with permission) and transcribed using an online software program called ‘Trent.’ The researcher sent transcripts of each interview to the study participants via email as a member check and to strengthen the validity of this section. Per Lincoln and Guba (1985), member checks are the most crucial technique for establishing credibility within qualitative research involving interviews. Participant C requested that her response to question two be revised to add more context. Participants D and J requested that grammatical edits be made to their responses. Revisions and grammatical edits requested by the three participants were included in the transcripts prior to coding.

The researcher coded the data using a grounded theory coding method by Auerbach and Silverstein (2003) to analyze participant responses on the simulation experience and create thematic categories. Grounded theory coding is a systematic methodology involving the construction of themes through the gathering and analysis of research data (Auerbach and Silverstein, 2003). Per the steps provided by Auerbach and Silverstein (2003), the researcher started by reviewing each interview transcript

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and highlighted text related to this research question. Next, the researcher grouped similar words or phrases stated by the participants, under repeating ideas. The researcher then examined each group of repeating ideas that were similar and established three themes. These themes were then connected to the theoretical frameworks utilized for this study to address this research question.

The third research question asked: *How do participants describe the impact of participating in a simulation-based training on their practice?*

To address this research question, the researcher utilized the post-simulation interview session to examine in what ways, if any, the participants believed the simulation training had an impact on their clinical practice. Identical to the data analysis methods utilized in research question two, participant responses were audio recorded and transcribed using 'Trent.' The researcher then sent the transcripts to the study participants as a member check. The researcher did not receive any comments or edits from the participants in relation to this research question. Through the utilization of the grounded theory coding method by Auerbach and Silverstein (2003), a fourth theme was established. The researcher then connected this theme to the theoretical frameworks utilized for this study to address this research question.

Summary

This chapter provided the methodological approach utilized to address the research questions presented in this study. Through the incorporation of mixed methods, the research addressed the research questions through the utilization of a pre- and posttest, a hemodynamics of cardiogenic shock simulation session, and post-simulation interviews with study participants. Participants of the study were comprised

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of 10 graduate medical education trainees (fellows) partaking in a simulation session located in a simulation center at a Pacific Northwest University hospital. Data from the study were analyzed through both qualitative and quantitative methods (paired sample *t*-test, AAC&U Critical Thinking VALUE Rubric (2009) and post-simulation interviews), to answer the questions presented in the study. Study results and findings are addressed in Chapter Four.

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Chapter 4: Research Findings

The purpose of this study was to examine the effects of a hemodynamic simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees to understand the potential of simulation-based training as an innovative tool to improve medical competencies among trainees in a graduate medical training program. Each research question presented in this study is evaluated in this chapter following the methodology and design described in Chapter Three. This chapter is organized into four sections. The first section describes the evaluation of participant's critical thinking through pre-and posttest results. The section describes the evaluation of participant's critical thinking through the utilization of the AAC&U VALUE Critical Thinking Rubric (2009). The third section describes the four themes that emerged from participant's post-simulation interviews. The fourth section provides a summary of the study findings.

Summary of Pre-and Posttest Results

To study the effects of a simulation-based training on the critical thinking skills of 10 graduate medical trainees, study participants completed a pretest one week before the hemodynamics of cardiogenic shock simulation session and a posttest one week after the simulation session. The pre-and posttest provided a clinical scenario that required participants to determine 'correct' next steps in identification and management of a patient with cardiogenic shock based on hemodynamics through five total questions. Three of the questions on the pre-and posttest were multiple choice and resulted in one 'correct' next step as it related to the clinical scenario. These questions were one point each for a total of three points. The last two questions on the

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exam were written response and required that participant's state the interventions needed to address the clinical scenario given in each question. Points assigned to the participants' response on these two questions were based on their level of critical thinking, specifically distinguishing between a rote response and one that required higher level thinking (Rotation Director, personal communication, 2017). The total amount of points a participant could receive on the pre-and posttest was thirteen. Information pertaining to the curricula used to create the pre-and posttest is provided in the sources of data section in chapter three. The pre/posttest and scoring rubric are provided in Appendix B.

One week prior to the hemodynamics of cardiogenic shock simulation session, the researcher sent the pretest to the 10 study participants electronically, via SurveyMonkey. Next, the posttest was sent to all 10 study participants one week after the simulation session. The Rotation Director graded all exams and provided scores for each study participant. Participant names were omitted from the exams when provided to the Rotation Director to lessen any potential grading bias. As defined by Centra and Gaubatz (2000), bias exists when a student, teacher, or course characteristic affects the evaluations made, either positively or negatively, but is unrelated to any criteria of good teaching, such as increased student learning. In this case, since the Rotation Director had prior exposure in teaching and supervising five of the 10 participants (second and third-year trainees) during the timeframe of the study, keeping the names of the participants listed on the pre/posttest may have created a bias in how the Rotation Director graded these exams. Table 9 displays the

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mean score and standard deviation of all 10 study participants at pretest and at posttest, by training year.

Table 9

Summary of Hemodynamics Pre-and Posttest Study Participant Scores by Training Year

Exam by Training Year	*M*	*SD*
Hemodynamics Pretest – 3rd Year	11.66	.57
Hemodynamics Posttest – 3rd Year	11.33	.57
Hemodynamics Pretest – 2nd Year	9.00	2.82
Hemodynamics Posttest – 2nd Year	10.00	.00
Hemodynamics Pretest – 1st Year	8.60	.55
Hemodynamics Posttest – 1st Year	9.00	1.87
Grand Total All Years – Pretest	9.60	1.77
Grand Total All Years – Posttest	9.90	1.66

Note. $n = 10$, * $p > .05$

In analyzing pre/posttest scores, a paired samples *t*-test revealed that all 10 trainees showed a small growth in hemodynamic knowledge from pre-to post by 0.30. While the data presented a growth in knowledge from pre-simulation to post-simulation, the overall pre-to post scores for all fellowship years was not statistically significant, $t(10) = -.667$, $p > .05$. In examining each training year, third-year trainees received the highest pretest mean score of 11.66 out of 13.00 or an average of 90% but regressed to a mean of 11.33 or 87% on the posttest. The researcher inquired with the Rotation Director about the decrease in score from pre-to post for two of the third-year

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fellows, to determine a root cause. The Rotation Director stated that Participants B and C lost a point in questions four and five due to the absence of a procedural step in the management of the hemodynamic patient (Rotation Director, personal communication, 2017). Determining the reasons why both participants missed a procedural step in the posttest may be due to several factors beyond the scope of this study.

Second-year trainees received the second highest pretest mean score of 9.00 out 13.00 or an average of 69%. Their average mean score on the posttest showed an increase of 1.00 point, with a total mean score of 10.00 or 77%. First-year trainees received the lowest pretest mean score of 8.60 out of 13.00 or an average of 66%. The first-year trainees did show growth in hemodynamic knowledge on the posttest, with a total mean score of 9.00 or 69%. Overall, all 10 study participants received an average mean score of 9.60 out of 13.00 on the pretest, placing them at a 74% in hemodynamic knowledge prior to the simulation. After the simulation, study participants showed an increase in their hemodynamic knowledge (overall), with an average mean score of 9.90 or 76%.

The researcher provided the Rotation Director with the pre/posttest score report and inquired about his thoughts on how the study participants scored overall. The Rotation Director stated that the scores reflected similarly to where he believed cardiovascular medicine fellow would be in their overall procedural and theoretical knowledge of the management of cardiogenic shock based on hemodynamics, per their fellowship training year (Rotation Director, personal communication, 2017). The Rotation Director's perception on the procedural and cognitive progression of trainees is similar to that of the Five-Stage Model of Adult Skill Acquisition by Dreyfus and

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Dreyfus (1980) that states that individuals must progress through each stage of expertise and must draw on their experiences of solving problems in context to reach higher levels of expertise. Furthermore, as explained in the theoretical framework section of chapter two, the Dreyfus and Dreyfus (1980) Five-Stage Model of Adult Skill Acquisition is currently the basis for competency assessment among graduate medical trainees as modeled in the ACGME Internal Medicine Milestones (2017). The results of the pre/posttest overall score report affirmed a progression in critical thinking skills from the beginning of fellowship training (first-year trainees), to the end of fellowship training (third-year trainees).

Summary of Critical Thinking Rubric in the Simulation Setting

The AAC&U Critical Thinking VALUE Rubric (2009) was used during the study to rate participants on their critical thinking skills as revealed by their actions in relation to the management of a patient with cardiogenic shock based on hemodynamics during the simulation. The AAC&U Critical Thinking Rubric (2009) was established by the Association of American Colleges and Universities (AAC&U) to evaluate and discuss student learning at all undergraduate levels within a basic framework of expectations such that evidence of learning can be shared nationally through a common dialog and understanding of student success. No modifications were made to the AAC&U Critical Thinking Rubric (2009), for the study.

To determine how the study participants rated on the AAC&U Critical Thinking VALUE Rubric (2009), as revealed by their actions during the hemodynamics of cardiogenic shock simulation session, the researcher conducted frequency counts of the percent of the participants at each level (i.e. benchmark,

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milestones, capstone), on each dimension (i.e. explanation of issues, evidence, influence of context and assumptions, student's position, conclusions and related outcomes), to determine each participant's critical thinking level as defined by the AAC&U Critical Thinking VALUE Rubric (2009). Tables 10 and 11 describe the participant levels and dimensions within the AAC&U Critical Thinking VALUE Rubric (2009). The researcher then calculated the mean of the overall score of participants' critical thinking scores on the rubric. Table 12 provides a summary of the raters' scores of the simulation participants per the AAC&U Critical Thinking VALUE Rubric (2009).

Table 10

AAC&U Critical Thinking VALUE Rubric (2009) - Description of Levels

Learner Level	Description of Level
Benchmark [Point-value: 1]	Skill is evident, but performance is at basic, early learner level
Milestones [Point-value: 2-3]	Skill is developing to proficient, performance is at mid-level learner level
Capstone [Point-value: 4]	Skill is mastery, performance at senior learner level

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Table 11

AAC&U Critical Thinking VALUE Rubric (2013) – Description of Dimensions

Dimension	Description of Dimension
Explanation of issues	The student clearly states the problem/issue and includes any information necessary to fully explain the issue.
Evidence	The student selects appropriate evidence to thoroughly investigate the problem, and critically evaluates the viewpoints. Expert opinions are questioned and not simply taken as fact.
Influence of context and assumptions	The student thoroughly analyzes their own and others' assumptions and includes relevant contextual information.
Student position (perspective, thesis/hypothesis)	The student presents a hypothesis that takes into account the complexities of the issue. The student acknowledges the limitations of their perspective, and the student includes both the merits and shortcomings of other points of view.
Conclusions and related outcomes	The student's conclusions are logically tied to the evidence, opposing viewpoints are presented, and the consequences and implications of the conclusions are outlined.

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Table 12

Participant AAC&U Critical Thinking VALUE Rubric (2009) Summary

Participant Name	Gender	Fellowship Year	Explanation of issues	Evidence	Influence of context and assumptions	Student's position	Conclusions and related outcomes	Grand Total
A	Female	3	3.8	4.0	3.7	4.0	3.8	3.9
B	Female	3	3.8	4.0	3.7	4.0	3.8	3.9
C	Female	3	3.8	4.0	3.7	4.0	3.8	3.9
D	Male	2	3.0	3.3	3.3	3.0	3.3	3.2
E	Male	2	3.0	3.3	3.3	3.7	3.3	3.3
F	Female	1	2.0	2.0	1.7	2.0	1.7	1.9
G	Female	1	2.0	2.0	1.8	2.3	1.7	2.0
H	Male	1	2.0	2.0	1.8	2.0	1.7	1.9
I	Male	1	2.0	1.7	1.3	1.2	1.7	1.6
J	Male	1	2.0	2.0	1.3	1.3	1.7	1.7
Grand Total			2.8	2.8	2.6	2.8	2.7	2.7

Benchmark: 1

Milestones: 2 – 3

Capstone: 4

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In examining study participant AAC&U Critical Thinking VALUE Rubric (2009) scores, third-year trainees received the highest score in all five critical thinking dimensions from all three raters, with a mean score of 3.9 or at a high 'milestone' performance level. Moreover, all three, received identical scores from all three raters in each critical thinking dimension. Second-year trainees received a mean score of 3.3 from all three raters, placing them at a low 'milestone' performance level. In reviewing the score report for the second-year trainees, both participants received identical scores in four of the five critical thinking dimensions. In the dimension of 'Student's Positions,' Participant D received an average score of 3.0 and Participant E received an average score of 3.7. When discussing the discrepancy in score with all three raters, they reported that Participant E took more of a leadership role during the simulation and initiated the patient care decisions (Study Raters, personal communication, September 14, 2017).

First-year trainees received a mean score of 1.8 from all three raters, placing them at a low 'benchmark' performance level in all five dimensions of critical thinking. In examining first-year trainee scores, raters reported 'Evidence' as the dimension that showed the highest critical thinking, with a 2.0 or at 'milestone.' Furthermore, raters reported 'Influence of context and assumptions' as the dimension that showed the lowest level of critical thinking, with a 1.6 or at 'benchmark.' When reviewing first-year trainee scores with raters, they reported that these study participants seemed unsure of their clinical judgment and unprepared to manage a hemodynamic patient (Study Raters, personal communication, September 14, 2017).

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A summary (Total Score) of the AAC&U Critical Thinking VALUE Rubric (2009) findings show increased critical thinking in their use of hemodynamics to manage patient with cardiogenic shock, per training year. These findings also are consistent with the Five-Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus (1980) that state that individuals must progress through each stage of expertise and must draw on their experiences of solving problems in context to reach higher levels of expertise. While the research study showed an increase in knowledge through the progression of training year, there are currently no other research studies pertaining specifically to an ACGME cardiovascular medicine fellowship training program that uses the AAC&U Critical Thinking VALUE Rubric (2009), to evaluate trainees on critical thinking.

The researcher also reviewed the average scores of study participants per training year, as graded by each rater, to determine interrater reliability. Table 13 shows these findings. In evaluating the intraclass correlation coefficient of all three participant scores per study participant, the average measure equals .990. These results indicate a "high" rate interrater reliability.

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Table 13

Average of Score – Training Year

Fellowship Year	Rater	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Grand Total
1	NP	2.0	2.0	1.2	1.7	1.0	1.6
	RD	2.0	1.8	1.6	1.6	2.0	1.8
	PD	2.0	2.0	2.0	2.0	2.0	2.0
Average Score		2.0	1.9	1.6	1.8	1.7	1.8
2	NP	3.0	3.0	4.0	3.5	3.0	3.3
	DS	3.0	4.0	3.0	3.5	3.0	3.3
	JG	3.0	3.0	3.0	3.0	4.0	3.2
Average Score		3.0	3.3	3.3	3.3	3.3	3.3
3	NP	3.5	4.0	3.0	4.0	3.5	3.6
	DS	4.0	4.0	4.0	4.0	4.0	4.0
	JG	4.0	4.0	4.0	4.0	4.0	4.0
Average Score		3.8	4.0	3.7	4.0	3.8	3.9

NP = Nurse Practitioner / RD = Rotation Director / PD = Program Director

In examining each raters' average scores, the overall score report showed that the Nurse Practitioner rated study participants with a higher stringency than the Rotation Director and Cardiovascular Medicine Program Director. When reviewing these results with the Nurse Practitioner, she stated that her expectations of the trainees may have caused her to score the study participants with more scrutiny (Nurse Practitioner, personal communication, January 19, 2018). As discussed in the pre/posttest section of this chapter, an educator's bias in student expectations are generally unintentional and are often a manifestation of an educator's expectations for student achievement and attainment (Gershenson, 2006). As a result, the effect of teacher expectations on student achievement, or the self-fulfilling prophecy effect, as

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established by Rosenthal and Jacobson (1968), can have an influence on a students' achievement. Per Iwasiw and Goldenberg (1993), when an educator has high expectations for learners, regards them as capable, and expects them to do well, that educator may attempt to teach more and create a more positive atmosphere.

In addition, the Nurse Practitioners' contact with the study participants is often limited to her interaction with the trainees when scheduled in the cardiovascular intensive care unit. The Program Director and Rotation Director have increased interactions with the study participants per the demands of their roles (fellow check-in) and as supervising attendees in the weekly fellow's clinic. Therefore, the amount of interaction that the Program Director and Rotation Director have with the study participants may have influenced their scoring of the trainees during the hemodynamics of cardiogenic shock simulation. As a result, the amount of interaction that each rater has to a trainee may have cultivated a bias in how they evaluated the trainees' procedural and theoretical knowledge.

A summary of AAC&U Critical Thinking VALUE Rubric (2009), study findings report that third-year trainees received the highest critical thinking scores from raters, at an average of 3.9 or at 'milestone,' while first-year trainees received the lowest critical thinking scores from raters, at an average of 1.8 or at 'benchmark.' Second-year trainees received an average score of 3.3 from the raters, placing them at 'milestone.' Simulation participant mean scores show a correlation in progression of training year to increased critical thinking in their use of hemodynamics to manage patient with cardiogenic shock. Study findings also reported a "high" rate of interrater

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reliability, with the highest simulation participant scores from the Program Director and the lowest simulation participant scores from the Nurse Practitioner.

Summary of Themes from Post-Simulation Interviews

The qualitative technique utilized for this study involved post-simulation interviews. Through the interviews, the researcher examined the prior experience that participants had with simulation training and how they viewed the incorporation of simulation in graduate medical training programs. Additionally, the researcher evaluated in what ways, if any, the participants believed the simulation training had an impact on their clinical practice. Table 14 provides a summary of the post-simulation interview participants.

Table 14

Post-Simulation Interview Participant Description Summary

Participant name	Identification	Post-graduate year	Training year
Participant B	Female	6	3
Participant C	Female	6	3
Participant D	Male	5	2
Participant E	Male	5	2
Participant G	Female	4	1
Participant H	Male	4	1
Participant J	Male	4	1

Through the utilization of a grounded theory coding method by Auerbach and Silverstein (2003), the researcher established four themes that emerged from all seven interviews. These themes are: (a) discrepancies in frequency and classification of

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simulation training, (b) the simulation learning environment, (c) from theory to practice, and (d) the impact of simulation training on clinical practice. Study findings related to all four themes and connections to current medical education research are included for each of the themes addressed.

Theme 1: Discrepancies in Frequency and Classification of Simulation Training

When the researcher asked the interview participants about their previous experience with simulation in graduate medical education, their responses indicated a variance in frequency and classification of simulation training. Participant D (second-year trainee) and Participant H (first-year trainee) reported that they had no prior experience with simulation. Participant D stated, “I have had no experience with simulation prior to this one.” Participant H said, “The only other graduate medical education experience I had was at [omitted] and we didn't have any sim training there.” Participant C (third-year trainee) and Participant B (third-year trainee) reported fragmentary experiences with prior simulation during both residency and fellowship training. Participant C stated, “We did central lines in my first year, but that was before we started fellowship, but nothing really since then.” Participant B said, “Very little. We did a simulation session I believe one or two maybe in medical school and then we did one before starting fellowship.”

Participants E (second-year trainee), G (first-year trainee), and J (first-year trainee) described prior experiences with simulation that were more robust in volume and scope. Participant E stated, “We actually used simulation extensively in residency primarily for code training, so mock codes, but also for some general ICU sickness trouble shooting.” Participant E continued to state, “We also used the mannequin lab

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for procedural training." Participant G said, "In residency, I frequently had outpatient simulation, like clinic simulation." Participant G also stated, "We did simulation that was similar to what we did for inpatient, like codes. We also did central line training, so those kinds of things." Participant J stated, "In residency we had frequent simulations generally surrounding ACLS care and some sort of hemodynamic compromised situations and we had that available to us in a couple different settings in our residency program."

McLaughlin et al. (2008), state that the use of medical simulation in graduate medical education is increasing in part because of limitations of the 80-hour resident work week, a greater emphasis on patient safety, and the importance of early acquisition of complex skills before actual operative or procedural practice. While a few programs have transformed their residency curriculum to fully integrate medical simulation, most have employed simulation less comprehensively (McLaughlin et al., 2008). Furthermore, the ACGME requirements for Internal Medicine (2013), programs state that an IM program may use simulation and skills laboratories in any manner they believe adequate to the competency goals of their educational program. A summary of the seven participants' experience with prior simulation in graduate medical education affirmed a discrepancy in the exposure and frequency that GME programs are incorporating simulation training within their curriculum.

To improve education and enhance patient safety, healthcare professionals are using simulation in many forms, including simulated and virtual patients, static and interactive manikin simulators, task trainers, and screen-based simulators (Aggarwal et al., 2010). Additionally, McLaughlin at al. (2008), assert that through a variety of

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simulators, programs can provide learners with an opportunity to practice critical, time-sensitive skills without risk to patient or learner. Skills such as Advanced Cardiovascular Life Support (ACLS) can be taught to a trainee away from distractions of the clinical environment and can allow time for rehearsal before application to a patient encounter (McLaughlin et al., 2008). Per Wayne et al. (2005), simulation is an ideal modality to allow deliberate practice in a wide variety of clinical scenarios, with opportunities for repetition and feedback.

When participants recalled the types of simulation that they were exposed to within graduate medical education, four of the participants reported central line training and mock code training, while three of the participants appeared divided when considering Advanced Cardiovascular Life Support (ACLS) training a form of simulation. Participant J classified ACLS as simulation training stating, "Mostly during internship and residency we had frequent simulations generally surrounding ACLS care." Participant J continued to state, "Part of our ACLS training we had sim man and we did training on that." Participants D and H did not view ACLS as a form of simulation, citing the format that the training was administered as the determining factor.

The American Heart Association ACLS certification guidelines (2015), state that trainees are required to complete a computer-based exam with a score of 84% and demonstrate the ability to lead a healthcare team through a ten-minute, in-person, "mega code" (cardiac arrest) simulated scenario. As conveyed by Participant H regarding the format of the ACLS course, "You are on the computer and you do all the cases and when you go in, you just do skills testing, and that's not really sim training."

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Participant D stated, “I look at ACLS differently, it’s just like a course rather than an actual simulation like what was done before.” Participant D continued to state, “If I have to answer the question regarding my prior experience in the simulation lab [with regards to ACLS], then yes, but viewing it like an actual simulation session, like what we did for the hemodynamics of cardiogenic shock simulation scenario, then no.”

Per Morgan and Cleave-Hogg (2005), computer programs, standardized patients, video scenarios, and interactive technologies can be viewed as ‘simulations,’ as each have value and particular educational outcomes. Moreover, Al-Elq (2010) defines simulation-based medical education as any educational activity that utilizes simulative aides to replicate clinical scenarios. A summary of the seven participants’ responses regarding the types of simulation training that they participated in graduate medical education conveyed a slight contrast in how they labeled simulation training. Specifically, the format that the simulation was conducted caused two participants to disregard ACLS as a form of simulation training. While the ACGME recommend that GME programs incorporate simulation and skills laboratories in their curriculum, the format that they administer simulation is at the discretion of the educational program (ACGME Program Requirements for Internal Medicine Programs, 2013). Currently, most GME program utilize the ACLS course as a way to incorporate simulation within their curriculum (McLaughlin et al., 2008).

Aggarwal and Darzi (2006), state that the principal use for simulation in the domain of technical competence is to provide learners with an opportunity for deliberate practice. Furthermore, simulation-based medical education can offer distinct educational advantages, especially for learning how to recognize and treat complex

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clinical problems (Good, 2003). Participant responses when recalling their prior experience with simulation training in graduate medical education present a discrepancy in the frequency that GME programs are utilizing simulation within their curriculum as well as a slight variation in how trainees classify types of simulation training. Aggarwal et al. (2010), argue that the success of simulation as an exercise is dependent not so much on the level of fidelity, but on how the trainee and the training program use simulation. As noted, the current ACGME requirements for IM programs state that while simulation and skills facilities must be available for all trainees, an IM program may use simulation and skills laboratories in any manner they believe adequate to the competency goals of their educational program (ACGME Program Requirements for Internal Medicine Programs, 2013). In addition, the ACGME does not currently provide any recommendations for IM programs on how to incorporate simulation training within their curriculum.

Theme 2: The Simulation Learning Environment

A second theme that emerged from the participant interviews focused on the simulation learning environment. Specifically, the ability to learn with minimal risk and reduced pressure was reiterated by all seven of the interview participants as positive aspects of the simulation environment. Zayapragassarazan et al. (2016), state that effective learning involves providing students with a sense of progress and control over their own learning. This requires creating an environment where learners have a chance to try out or test their ideas (Zayapragassarazan, et al., 2016). Moreover, the learning climate should be one that causes adults to feel accepted, respected, and supported where there is freedom of expression without fear of punishment or ridicule

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(Knowles, 1980). Per Knowles (1980), the learning environment should be one that makes adults feel at ease in order to establish a positive learning environment for all learners.

According to Jones et al. (2015), simulation-based medical education can provide a safe, controlled environment where problem-based learning is developed, and competences are practiced. Furthermore, simulation can allow users at all levels, from novice to expert, to practice and develop skills with the knowledge that mistakes carry no penalties or fear of harm to patients or learners (Bradley, 2006). Four of the seven participants reported that simulation did provide them with a learning environment that was non-stressful and gave them the opportunity to think through their clinical actions during the scenario. Participant G stated, “I think it was a good experience to recognize room for improvement, and learning opportunities, it’s always good to think about these things in a non-stressful environment as well.” Participant E said, “This was an opportunity to operationalize what you know and solidify the thought process, and differential diagnosis, in a setting where there are no consequences.” Participant D reported, “It allows us to have a patient scenario without the added pressure of the patient there.” Participant J stated, “As a whole, the simulations I've done over time have been very useful in terms of sort of developing comfort with acute life-threatening situations in a lower stress situation and sort of going through the steps and being then prepared to lead situations where there is an acute life-threatening situation.”

Per Gordon et al. (2001), allowing learners to live through a realistic experience, while making mistakes in a safe environment, is a primary advantage of

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simulation training. Furthermore, simulation- based medical education can create conditions where making mistakes is not harmful or dangerous to patients but is, rather, a powerful learning experience for students (Ziv, Ben-David, & Ziv, 2005). Three of the seven participants reported that the simulation environment provided them the opportunity to practice clinical skills and apply theoretical knowledge with the ability to make mistakes that did not harm any patients. Participant C stated, "There's no actual consequences to it [simulation], so I think it's just a really good way to make clinical decisions in a way where you're not actually hurting somebody with it." Participant B reported, "It's kind of nice to be able to afford to be wrong without negative consequences in the real world, and I think that's something that is really important because we all make mistakes." Participant H said, "There is pressure but it's not the pressure of doing something wrong and having someone lose their life." As affirmed by Gordon et al. (2001), the simulated environment can allow trainees to "live through" an array of important medical cases without the issue of patient safety.

Another element of the simulation environment that was brought up by two participants during the interviews focused on the positive aspects of observing and learning from peers during simulation scenarios. Participant C stated, "I actually really liked working with my colleagues and seeing how they were thinking about things that I wasn't necessarily thinking about and being able to go back and reflect on what they said." Participant B also stated, "You get to see how other people approach the problem and what do they focus on and you know you learn from each other. It's like role modeling essentially." Nestel and Kidd (2003), state that student-led groups often work together to achieve set goals by exchanging ideas and experiences of related

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knowledge, attitudes, and skills. Furthermore, the quality of human interaction among health professionals is an essential element in optimal delivery of healthcare (Ziv et al., 2005).

Per Ziv et al. (2005), a pivotal feature of simulation-based medical education is that it can provide medical students and professionals with an opportunity to learn through their own mistakes. Moreover, the simulated learning environment can allow learning and re-learning as often as required to correct mistakes, allowing the trainee to fine-tune skills to optimize clinical outcomes (Lateef, 2010). A summary of the seven interview participant responses found that a positive simulation experience was one that cultivated a low-risk, minimal-pressure environment. In addition, an optimal simulation environment allowed trainees to make mistakes and think through scenarios to refine their theoretical knowledge and practice their clinical skills. Currently, the challenge of simulation-based medical education for many programs is to simulate an authentic healthcare environment that will enable trainees to immerse themselves into the simulated scenarios as a real scenario, and to maximize the learning from the simulation (Ziv et al., 2005). As stated by the cardiology program director, "It takes time and often many resources to create a meaningful simulation, and one that will cultivate a positive learning environment for trainees" (Program Director, personal communication, January 14, 2018).

Theme 3: From Theory to Practice

Another theme that emerged from participant interviews focused on the simulation providing an opportunity for trainees to apply their theoretical knowledge regarding hemodynamics of cardiogenic shock to practice in the simulation setting.

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Participants B and C were third-year trainees and had received comprehensive theoretical knowledge regarding hemodynamics of cardiogenic shock through didactic conferences and rotating on the CVICU more than three times during their training. Participants D and E were second-year trainees and had received some theoretical knowledge regarding hemodynamic of cardiogenic shock through didactic training and rotating on the CVICU at least once during their training. Participants G, H, and J were first-year trainees and received some theoretical knowledge regarding hemodynamics of cardiogenic shock one hour prior to entering the simulation through a didactic lecture. The three participants also had no exposure to the CVICU prior to the simulation.

Traditionally, the medical education curriculum has been designed to provide a basis of medical science followed by clinical experience in a number of medical specialties (Morgan et al., 2006). However, Morgan et al. (2006) state that the complexity of cases, the number of learners, and patient safety can affect opportunities for hands-on experience in the clinical setting. As stated by Participant E, “A lot of what we learned is in the textbook or even in didactic and whether or not you know something, well it's important to operationalize.” The contrast between the ‘ideal’ as portrayed by theory and the ‘reality’ as experienced in the provision of patient care can play an essential role when trying to bridge the gap between theoretical knowledge and practical application (Phillips et al., 1998). Participant B reported, “You learn about hemodynamics or you learn about a certain thing and it's just so different when you actually see it in practice.” Moreover, Participant G stated, “I think having some background and some practice in those situations is actually very helpful.”

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Knowles, Holton III, and Swanson (2014) state that adults learn new knowledge, skills, values, and attitudes most effectively when they are presented in the context of application to real-life situations. Per Morgan et al. (2006), simulation can offer unique opportunities to provide hands-on learning as well as a learning environment that allows students to apply theory to practice. As stated by Participant E, “It [simulation] allows you to take scenarios you might be familiar with hemodynamically but apply them in a point of care setting and act upon them.” Additionally, simulations can be used to help learners acquire new knowledge, and to better understand conceptual relations and dynamics within complex patient care, in a safe environment (Gaba, 2004). Participant H stated, “The more practice you have with evaluating the situation critically, I think the better you will be when the actual situation turns up.” Furthermore, Participant E reported, “This was an opportunity to operationalize what you know and solidify the thought process, differential diagnosis, in a setting where there are no consequences.”

Simulation also has the potential to recreate scenarios that are rarely experienced and test professionals in challenging situations, while carefully replaying or examining their actions (Aggarwal et al., 2010). Participant J reported, “Doing the simulations where you have an opportunity just to do that [triage, diagnose and treat] in a sort of slower or stress-free setting gives you the option to slow down a little bit and think through things and then bring that reasoning back to the situations where you're sort of on the spot and under a lot of stress.” Participant J continued to state, “You can pause and think, ‘What did I do previously?”, ‘How can I think through this situation?’ and determine what worked and what didn’t work.” Participant J

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concluded, “It’s a good opportunity to prepare that clinical reasoning.” Per Cioffi (2001), simulation can enable the learner to experience critical thinking in a more dynamic and natural manner than the traditional observer medical model, since they can be designed to attain a high degree of representativeness of actual clinical situations. As stated by Participant D, “I think this allows you to kind of go through all the thinking that goes with it [hemodynamics of cardiogenic shock], without the added pressure.”

Per Kolb (1984), learning is not so much the acquisition or transmission of content as it is the interaction between content and experience, whereby each transforms each other. The goal of a learning scenario is to provide adult learners with an opportunity to foster connections between experience and prior knowledge and new knowledge (Kolb, 184). Aggarwal et al. (2010), state that simulation can provide an opportunity for learning that is both immersive and experiential as it amplifies real-patient experiences that replicate aspects of the real world in an interactive matter. As stated by Participant C, “I think the nice part about simulation is that it is real enough that it feels like a genuine experience, but it's different enough that you remember it as a simulation.” During the interview, Participant C reported that after the simulation, she had a patient experience that presented her with the opportunity to identify and manage a patient with cardiogenic shock through the use of hemodynamics in the clinical setting. Participant C said, “It was like a direct example of the same clinical scenario where I was like, ‘Oh, I have seen this,’ I know that their heart rate should not be 50, we need to get their heart rate up because they are in cardiogenic shock.” Participant C was one of the participants who reported that the simulation had no

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direct impact on her clinical practice, as explained in theme two. This was the only major inconsistency in perception of simulation training on clinical skills that the researcher noted in the interviews.

When the researcher examined responses from interview participants regarding the effect of simulation on trainee learning, a connection between theory and practice emerged. Specifically, the assertion that simulation can provide an opportunity to bridge the gap between theoretical knowledge and practical application resonated among all seven interview participants. It is important to note while simulation can facilitate a learning process that is active and mimics clinical reality, it does not replace real clinical experience (Cioffi, 2001). Alternately, simulation can promote learning for understanding and meaning rather than rote learning of facts and principles (Higgs, 1992). As noted in theme two, there is no required format in how cardiology training programs incorporate hemodynamics of cardiogenic shock training into their curriculum. Per the cardiology program director, trainees currently receive theoretical knowledge regarding hemodynamics of cardiogenic shock through conferences, such as journal club, where trainees and faculty review current scholarly journal articles on current best medical practices and discuss incorporating elements in clinical practice, and a morbidity and mortality (M&M) conference. Trainees then have the opportunity to apply theory into practice when scheduled in the CVICU for one month at a time (Program Director, personal communication, January 14, 2018). The hemodynamics of cardiogenic shock simulation was the first time in the fellowship programs' history that hemodynamics of cardiogenic shock theoretical knowledge and practice was applied in a simulated scenario.

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Theme 4: The Impact of Simulation Training on Clinical Practice

Per Gaba (2004), simulation is a technique that can replace or amplify real-patient experiences with guided experiences, artificially contrived, that evokes or replicates substantial aspects of the real world in a fully interactive manner. Moreover, as an educational strategy, simulation can provide the opportunity for learning that is both immersive and experiential (Aggarwal et al., 2010). As asserted by Aggarwal et al. (2010), simulation is a powerful learning tool that can help the modern healthcare professional achieve higher levels of competence and safer patient care. Additionally, simulation has the potential to recreate scenarios that are rarely experienced, test professionals in challenging situations, and allow them to carefully replay or examine their actions (Leape et al., 1991). To examine the effects of the simulation experience, the researcher asked the seven interview participants to what extent the hemodynamics of cardiogenic shock simulation impacted their clinical practice.

Three participants reported that they could not determine if the simulation had any impact on their clinical practice due to not being on any clinical rotations that exposed them to patient with cardiogenic shock and the use of hemodynamics during the time of the interviews. Participant H, a first-year trainee, stated, “I’m only in the clinic right now where there is no critical care, so I haven’t really had an opportunity to implement it as of yet.” Participant H continued to state, “Everyone that I’ve seen has been pretty stable, so nothing critical has popped up for me, but once it does, I think I will feel a little more comfortable going into it.” Participant G, another first-year trainee, stated, “I haven’t really been on service recently, except for call.” Participant G continued, “I think now as a cardiology fellow I can use echo as a tool in

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a lot of these situations, whereas before I didn't have training in that." Participant G concluded, "I guess maybe it's too early to tell, but probably." Participant D, a second-year trainee, stated, "I think it's too early for me to say if it has or not only because I've had non-clinical rotations." Participant D concluded, "I've been in the Echo lab and I've been on research, so nothing in the Echo lab has required me to do this yet."

Two participants reported that the hemodynamics of cardiogenic shock simulation did not have a specific impact on their clinical practice and viewed it as just another learning experience. Participant J, a first-year trainee, stated, "I think this particular simulation didn't specifically impact my practice." Participant J explained, "I think it's sort of a useful refresher on some things and a useful learning experience, but in the context of all the simulations and all the clinical experiences, it is just sort of another tool we get to add on." Participant C, a third-year trainee, stated, "It's hard to state because we do this all the time, I was just on heart failure [rotation], and this was happening every day and we just worked through all of this." Participant C continued to state, "I think maybe it's hard to say, 'You know this is the way the simulation went, and this is how I directly translated it', but it's just another experience you draw on." Participant C concluded, "I think that all of these simulation experiences, you can translate into your practice and they all kind of come together, and you are constantly drawing on these little things."

Two participants reported that the simulation session could have a potential impact on their clinical practice in the future by making them more aware of how to use hemodynamics to manage a patient with cardiogenic shock in the clinical setting. Participant B, a third-year trainee, stated, "You learn about hemodynamics or you

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learn about a certain thing and it's just so different when you actually see it in practice." Participant B explained, "I feel more comfortable now assessing the situation and I feel more confident that I would be able to recognize some of these things in actual clinical practice." Participant B concluded, "It kind of validated, yes, this is what it will be like." Participant E, a second-year trainee, stated, "As a fellow, working through the hemodynamics simulation will certainly help me to slow down my thought process in a more acute scenario, to think through each of the components, and to utilize that information separately as opposed to what is often a common reaction to first critical care experiences, which is a little more chaotic."

When the researcher analyzed the participants' responses regarding the extent that participating in the hemodynamics of cardiogenic shock simulation had an impact on their clinical practice, five of the participants conveyed an indifference in the value of the simulation, citing little exposure and no direct need of hemodynamic skills in their current practice, while two participants expressed that it could be of future value within their clinical practice. To determine the reasons why most of the participants labeled the hemodynamics of cardiogenic shock simulation to be of impartial value within their learning, the researcher reviewed the interview responses with the cardiology Program Director. The Program Director believed the responses had a correlation to the amount of exposure the participants had to the management of a patient with cardiogenic shock through the use of hemodynamics during the time of the simulation (Program Director, personal communication, January 14, 2018).

As noted by the Program Director, first-year fellows are not scheduled in the cardiovascular intensive care unit (CVICU) during the first six months of their training

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(Program Director, personal communication, January 14, 2018). When the researcher asked why first-year trainees did not rotate in the CVICU within the first six months, the Program Director stated, “We do not schedule them in the CVICU due to the high patient volume and the complexity of the cases within the service.” The Program Director continued to state, “First-year trainees do not have the theoretical foundation yet to handle these complex patients and they need all the building blocks first, in order to provide adequate and safe patient care.” The Program Director concluded, “The CVICU is where the trainees would get exposure to hemodynamic-related cases, so it does not surprise me that so many of them did not find the simulation to be of value, as they don’t understand the importance of it yet.” Currently, there is a limited amount of research within medical education regarding how a trainee’s previous experiences can affect the value of a simulation training.

Another factor to consider when examining why most of the participants did not view the simulation as valuable relates to how adults define impactful learning experiences. Knowles (1984a) states that adults will spend more time and energy learning when they see a reason for learning. Therefore, adults need to know why they need to learn something before undertaking to learn it (Knowles, 1984a). Lieb and Goodlad (1991) explain that although many adults, especially those participating in learning activities voluntarily, will enter a learning situation with a clear sense of why it is important for them or their organization, others will not. Participants G, H, and J were first-year trainees, who had minimal exposure to hemodynamics of cardiogenic shock prior to the simulation and continued to have minimal exposure after the simulation due to the restriction of not being scheduled on the CVICU service within

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the first six months of their training. Participants D and E, who just began their second year in the training program, rotated on the CVICU only once before the simulation session. As a result, it may have been difficult for these participants to identify the simulation as impactful as they did not have a clear sense of why it was important for them to learn how to identify and manage a patient with cardiogenic shock through the use of hemodynamics in the clinical setting.

Jones et al. (2015), state that simulation can help to create a clear "need to know" among trainees since it mimics real life situations and gives trainees the chance to practice procedures within a safe, controlled environment, and the possibility to determine in advance how to address complex clinical cases. However, a summary of participant responses when determining the impact of the hemodynamics of cardiogenic shock simulation on their clinical practice presented an impartiality in the value of the simulation experience. Specifically, Participants D, G, and H conveyed that they could not determine a level of impact, while Participants J and C believed there was no direct impact of the hemodynamics of cardiogenic shock simulation on their clinical practice. Participants B and E noted that the hemodynamics of cardiogenic shock simulation could have an impact on their clinical practice in the future.

Factors relating to why most of the participants did not see much value in the hemodynamics of cardiogenic shock simulation focused on the amount of exposure that most of the participants had in the management of cardiogenic shock based on hemodynamics prior to the simulation and an unclarity for some participants in understanding the importance of the use of hemodynamics to manage patients with

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cardiogenic shock in the clinical setting. As stated by Hansman and Mott (2010), for adult learners, it is important to identify reasons for them to fully engage in the learning process. Moreover, the relevancy of new knowledge and skills can become central to the adult's learning process (Knowles, 1984a).

Summary of Research Study Findings

The purpose of this study was to investigate the effects of a hemodynamic simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees to understand the potential of simulation-based training as an innovative tool to improve medical competencies among trainees in a graduate medical training program. To examine the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees, the researcher:

1. Analyzed study participants pre-and posttest scores through a paired sample *t*-test to evaluate the participant's fund of hemodynamics of cardiogenic shock knowledge before and after the simulation session.
2. Analyzed the critical thinking skills of 10 graduate medical education trainees as scored by three raters using the AAC&U Critical Thinking VALUE Rubric (2009) during a hemodynamics of cardiogenic shock simulation session.
3. Examined if seven of the study participants believed that the simulation training had any impact on their critical thinking skills within their practice

Table 15 provides a summary of results for each study participant in all three areas of data collection and includes selected narratives to show in what ways, if any, the participants believed the simulation training had an impact on their clinical

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practice. In analyzing pre/posttest scores, a paired samples *t*-test revealed that all 10 trainees showed a growth in critical thinking regarding the management of a patient with cardiogenic shock based on hemodynamics from pre to post by 0.30. While the data presented a growth in knowledge from pre-simulation to post-simulation, the overall pre-to post scores for all training years was not statistically significant, $t(10) = -.667$, $p > .05$. Overall, the results of the pre/posttest score report showed a progression in critical thinking skills in relation to hemodynamics of cardiogenic shock from the beginning of fellowship training (first-year trainees), to the end of fellowship training (third-year trainees).

A summary of the AAC&U Critical Thinking VALUE Rubric (2009) study findings reported that third-year trainees received the highest critical thinking scores from raters, at an average of 3.9 or at ‘milestone,’ while first-year trainees received the lowest critical thinking scores from raters, at an average of 1.8 or at ‘benchmark.’ Second-year trainees received an average score of 3.3 from the raters, placing them at ‘milestone.’ Simulation participant mean scores show a correlation in progression of fellowship year to higher critical thinking skills. Study findings also reported a “high” interrater reliability among the three study raters. Post-simulation interviews with seven of the study participants reflected four major themes that included: (a) discrepancies in frequency and classification of simulation training, (b) the simulation learning environment, (c) from theory to practice, and (d) the impact of simulation training on clinical practice.

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Table 15

Summary of Study Participants Data Results

Participant Name	Gender	Fellowship Year	Pre-test	Post-test	Critical Thinking Rubric	Post-Simulation Interviews – Selected Narratives
A	Female	3	11	12	3.9	*Did not participate*
B	Female	3	12	11	3.9	"The nice part about simulation is that it is good because it's real enough that it feels like a genuine experience."
C	Female	3	12	11	3.9	"It's kind of nice to be able to afford to be wrong without negative consequences in the real world."
D	Male	2	7	10	3.2	"Working through the hemodynamics simulation will certainly help me to slow down my thought process in a more acute scenario."
E	Male	2	11	10	3.3	"I think it allows us to have a patient scenario without the added pressure of the patient there."
F	Female	1	9	9	1.9	*Did not participate*
G	Female	1	9	9	2.0	"I think it was a good experience to recognize room for improvement and learning opportunities."
H	Male	1	8	11	1.9	*Did not participate*
I	Male	1	8	10	1.6	"I think it kind of gives you an opportunity to assess the situation."
J	Male	1	9	6	1.7	"I would say that this specific session may not have had a huge impact on me."

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As conveyed throughout this research study, there is a vast amount of medical education research that conveys the positive aspects of incorporating simulation-based training in medical training programs. However, finding research that provides recommendations on how to incorporate connections to critical thinking in the simulation lab that is transferred into the clinical setting is minimal. Through a mixture of qualitative and quantitative techniques, this study reported an increase in the critical thinking skills of trainees in both procedural and clinical judgment, as related to hemodynamics of cardiogenic shock, through simulation-based training. Moreover, the study findings also showed that in order for trainees to value a simulation-based learning experience, they needed to understand the impact of that learning experience. Without meaning, the simulation experience became just another didactic training. Chapter five provides a summary of all the information gathered and presented in this research study and makes recommendations as to how graduate medical training programs can incorporate simulation-based training into their curriculum as a valuable experience both procedurally and cognitively, for graduate medical trainees.

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Chapter Five: Discussion, Conclusion, and Recommendations

In an age where practicing physicians have access to an overwhelming volume of clinical information and are faced with increasingly complex medical decisions, the ability to execute sound clinical reasoning is essential to optimal patient care (Cooke & Lemay, 2017). However, problems with clinical reasoning in the medical setting make up a sizable portion of preventable adverse outcomes (Iobst, et al., 2013). In 2013, Johns Hopkins' patient safety experts calculated that more than 250,000 deaths per year are due to medical error in the United States (Makary & Daniel, 2016). Medical errors related to clinical reasoning can often reflect a gap in a physician's cognitive process or metacognition (Graber et al., 2005). Cognitive factors such as misidentification of a patient's symptoms or a physician's insufficient knowledge of a relevant condition can have a major impact on patient care (Graber et al., 2005). Therefore, devising strategies for reducing cognitive error in the medical setting is imperative to the continuity of care for patients.

The acquisition of clinical reasoning through the development of critical thinking skills is an essential component of a physician's medical training (Maudsley & Strivens, 2000). In medical education training, the development of clinical reasoning is traditionally cultivated during clinical rotations (Schmidt & Mamede, 2015). However, today's clinical setting offers limited practice and at times, suboptimal supervision (Schmidt & Mamede, 2015). Per Schmidt and Mamede (2015), opportunities for medical trainees to critically review their own performance in today's clinical setting is limited. Changes in healthcare delivery have resulted in fewer opportunities for medical trainees to learn from a breadth of real patients.

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Moreover, the changing roles of healthcare professionals have also reduced opportunities to learn through practice (Khan et al., 2011). The array of limitations in the clinical setting can foster an inconsistency and potential bias in the assessment of a medical trainee's ability to utilize and refine their critical thinking skills when providing patient care (Jones et al., 2015). One way to address the gap in fostering critical thinking skills among medical trainees is through the utilization of simulation-based training.

Growing research acknowledging the benefits of simulation-based training (McGaghie et al., 2010), along with recent fundamental changes in the delivery of medical education, has accelerated the application of simulation in today's medical education curriculum (Willis & Van Sickle, 2015). In graduate medical education, the current ACGME Common Program Requirements for Internal Medicine (2013) state that programs must provide trainees with access to training using simulation. Per the ACGME Review Committee, simulation means that learning about patient care occurs in a setting that does not include actual patients. This can include objective structured clinical examinations, patient simulators, or electronic simulation of codes, procedures, and other clinical scenarios. Currently, an ACGME IM graduate medical education program can incorporate simulation and skills laboratories in any manner they believe adequate to the competency goals of their educational program.

While simulation-based training is increasing in popularity as a teaching strategy in many medical schools across the United States, locating research related to the examination of critical thinking skills through medical simulation-based training can be difficult (Daniel-Underwood, 2016). Studies related to simulation-based

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training in medical education often gravitate their focus toward the efficiency of simulation in achieving procedural competence (Bradley, 2006; Fernandez et al., 2007; Issenberg et al., 2005). However, the analysis of how learning takes place within the simulation environment, specifically, the integration of critical thinking skills within this setting, remains to be explored in graduate medical education. Therefore, there is a need to establish a link between simulation-based training and critical thinking in graduate medical education.

To aid in this research gap, the purpose of this study was to investigate the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees. The goal of this study was to understand the potential of simulation-based training as a tool to improve medical competencies among trainees in a graduate medical training program. To examine the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical education trainees, three research questions guided this study:

1. How do the participant's rate on critical thinking skills on the AAC&U Critical Thinking VALUE Rubric (2009), as revealed by their actions during a simulation?
2. What is the effect of a simulation-based training on participants' critical thinking skills?
    a. As revealed through participant pre/posttest scores?
    b. As revealed through interviews with participants regarding their perspective on a simulation experience?

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3. After the simulation, how do participants describe the impact of participating a the simulation-based training on their clinical practice?

Discussion

To examine the effects of a simulation-based training experience on the critical thinking skills of 10 graduate medical trainees, study participants completed a pretest one week before a hemodynamics of cardiogenic shock simulation session and a posttest one week after the simulation session. Next, the AAC&U Critical Thinking VALUE Rubric (2009) was utilized during the study to rate participants on their critical thinking skills as revealed by their actions during the hemodynamics of cardiogenic shock simulation. Finally, post-simulation interviews were conducted with seven of the study participants to examine the impact of the simulation experience on their clinical practice.

In analyzing pre/posttest scores, a paired samples *t*-test revealed that all 10 study participants showed an increase in hemodynamic knowledge from the pretest to the posttest by 0.30. An increase in hemodynamic knowledge may be the result of the simulation environment as examined in the post-simulation interviews. Specifically, participants stated that the simulation provided them with an opportunity to apply their theoretical knowledge regarding the management of a patient with cardiogenic shock based on hemodynamics, in a safe learning environment. Moreover, the simulation allowed participants to make mistakes and experience the results of their actions, in a simulated clinical environment, without any real patient harm.

The results of the pre/posttest also showed an overall progression in hemodynamics of cardiogenic shock knowledge from the beginning of fellowship

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training (1st year mean post score = 9.00) to the end of fellowship training (3rd year mean post score = 11.33). A progression in knowledge regarding hemodynamics of cardiogenic shock through training year was also reflected in the AAC&U Critical Thinking VALUE Rubric (2009) score report. A summary of the rubric findings showed that third-year trainees received the highest critical thinking scores, at an average of 3.9 or at ‘milestone,’ while first-year trainees received the lowest critical thinking scores, at an average of 1.8 or at ‘benchmark.’ The progression of knowledge regarding hemodynamics of cardiogenic shock in training year may be the result of prior training involving the use of hemodynamics to manage a patient with cardiogenic shock as reflected in post-simulation interviews. The participants stated that the simulation provided them with an opportunity to apply their prior knowledge of hemodynamics as related to cardiogenic shock, whether it was theoretical (1st year) or a mixture of theoretical and clinical (3rd year) and determine best practices in managing a patient with cardiogenic shock.

The progression of hemodynamics of cardiogenic shock knowledge in training year on the pre/posttest and the AAC&U Critical Thinking VALUE Rubric (2009) may also reflect the value that trainees placed on the acquisition of this medical competency in their current clinical training. As acknowledged in the post-simulation interviews, first-year participants expressed difficultly in determining the impact of the training due to being on clinical rotations that did not require them to use hemodynamics to manage a patient with cardiogenic shock. Therefore, they did not see a direct value in the simulation experience. Some of the second and third-year participants did acknowledge the simulation to be of value to their clinical practice,

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stating that the simulation provided them with an opportunity to examine their knowledge of hemodynamics as related to cardiogenic shock. Furthermore, the participants also stated that the simulation could aid in their ability to successfully recognize and treat a patient with cardiogenic shock through the use of hemodynamics in the clinical setting.

Conclusions

There is a vast amount of medical education research that convey the positive aspects of incorporating simulation-based training in medical training programs (Baker, 2004; Daniel-Underwood, 2016; Fernandez et al., 2007; Jones et al., 2015; Khan et al., 2011; Lewis et al., 2012). However, research related to the impact of simulation-based training on the critical thinking skills of graduate medical education trainees is minimal. The goal of this study was to understand the potential of simulation-based training as a tool to improve medical competencies among trainees in a graduate medical training program. Through a mixture of qualitative and quantitative techniques, this study investigated the effects of a hemodynamics of cardiogenic shock simulation-based training experience on the critical thinking skills of 10 graduate medical trainees. This research study generated the following assertions from the data results.

In this study, simulation-based training provided trainees with an opportunity to apply theory to practice, in a safe learning environment. Traditionally, the medical education curriculum is designed to provide a basis of medical science followed by clinical experience (Morgan et al., 2006). However, the complexity of cases, the number of learners, and patient safety can affect opportunities for hands-on experience

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in the clinical setting (Morgan et al., 2006). In post-simulation interviews, participants stated that the simulation provided them with an opportunity to apply their theoretical knowledge of the hemodynamics of cardiogenic shock, in a safe learning environment. Furthermore, the ability to learn with minimal risk and reduced pressure was reiterated by all seven of the interview participants as positive aspects of the simulation environment. Per Zayapragassarazan et al. (2016), effective learning involves providing students with a sense of progress and control over their own learning. This requires creating an environment where learners have a chance to try out or test their ideas (Zayapragassarazan, et al., 2016). The simulation environment provided study participants with the opportunity to practice clinical skills and apply theoretical knowledge, with the ability to make mistakes that did not harm any patients.

In this study, trainees progressed in their critical thinking (as related to hemodynamics of cardiogenic shock) through each training year. The results of the pre/posttest overall score report showed a progression in critical thinking skills from the beginning of fellowship training (first-year trainees), to the end of fellowship training (third-year trainees). Similarly, a summary (Total Score) of the AAC&U Critical Thinking VALUE Rubric (2009) findings showed an increase in critical thinking regarding the management of a patient with cardiogenic shock based on hemodynamics per training year. These findings are consistent with the Five-Stage Model of Adult Skill Acquisition by Dreyfus and Dreyfus (1980) that state medical trainees must progress through each stage of expertise and must draw on their experiences of solving problems in context to reach higher levels of expertise.

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Per the Dreyfus and Dreyfus Model (1980), first-year participants' critical thinking scores reflected a medical trainee in the first (novice) and second stage (advanced beginner) of knowledge development. Trainees in these stages can recognize common situational aspects in their patient cases, but they are still learning the process, protocols, and procedures of their specific medical training. Second-year participants' critical thinking scores reflected a medical trainee in the third stage (competence) of Skill Acquisition (1980). These trainees depend on standard procedures as a base of consideration, but they can also modify their patient care if necessary. Third-year participants' critical thinking scores reflected a medical trainee in the fourth stage (proficient) of Adult Skill Acquisition (1980). These medical trainees have the ability to streamline procedures unconsciously and are proficient in managing conflicting medical situations. Per Dreyfus and Dreyfus (1980), all medical learners completing specialty training should be at this level.

None of the study participants received a capstone score of 4.0 on the AAC&U Critical Thinking VALUE Rubric (2009), or a perfect score of 13.00 points on the pre/posttest, that would have placed them at the final stage (expert) of Adult Skill Acquisition (1980). Per Dreyfus and Dreyfus (1980), medical trainees in the final stage (expert) of Adult Skill Acquisition can perform intuitively in synthesizing medical and psychological influences into fluid, flexible, and efficient care plans. In this stage, medical trainees require no supervision and are self-regulated in their learning. Thus, the expert trainee is considered unconsciously competent (Dreyfus & Dreyfus, 1980). While no participant scored in the expert stage, most study participants demonstrated a progression in hemodynamic knowledge after the

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simulation training. Furthermore, as discussed in the post-simulation interviews, participants stated that the simulation provided them with an opportunity to receive hands-on learning, as well as a learning environment that allowed them to apply theory to practice and determine best practices for managing a hemodynamic patient.

This study found that in order for a trainee to consider a simulation to be impactful, the training must be relevant to their current clinical practice. Knowles (1984a) states that adults will spend more time and energy learning when they see a reason for learning. Therefore, adults need to know why they need to learn something before undertaking to learn it (Knowles, 1984a). In the post-simulation interviews, first-year participants expressed difficultly in determining the impact of the hemodynamics of cardiogenic shock simulation training due to being on clinical rotations, that did not require them to manage hemodynamic patients. Moreover, first-year trainees are not scheduled on the cardiovascular intensive care unit within the first six months of their training. This CVICU is where trainees would be exposed to a hemodynamic patient. As a result, these participants were indifferent to the impact of the simulation as they did not have a need to manage hemodynamic patients in their current clinical practice.

Second and third year participants had prior experience in the cardiovascular intensive care unit before the simulation that provided them with an exposure to hemodynamic patients. It also provided them with an understanding of the importance in being able to properly identify and manage a patient in hemodynamic shock. As asserted by Bryan, Kreuter, and Brownson (2009), for adult learners, it is important to identify reasons for them to fully engage in the learning process. The simulation

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provided these trainees with a safe space to assess their procedural and theoretical knowledge of hemodynamics as related to cardiogenic shock. As a result, the second and third-year participants who did acknowledge the simulation to be of value to their clinical practice stated that the simulation provided them with an opportunity to examine their current knowledge of hemodynamics of cardiogenic shock and determine best practices.

Limitations

The major limitations of this study included the limited time period to conduct the simulation and the small size of study participants. Graduate medical education programs in the U.S. begin their academic year in July and within fellowship programs, introduction didactics are typically scheduled during the summer to prepare fellows for their clinical training. The hemodynamics of cardiogenic shock simulation was scheduled by the Program Director during August to adhere to the programs didactic training schedule. With this, the researcher had a limited window of when the simulation session could be conducted.

The researcher also had a limited size of participants for the study. Per the Program Director, most medical fellowship training programs have about 14 trainees at max. There are 14 trainees in the researcher’s fellowship program. The researcher did contact all 14 trainees regarding their participation in the study. However, four of the trainees were unable to participate in the study due to a cardiology related conference that each had permission from the Program Director to attend. Therefore, only 10 trainees participated in the study. This small number of participants caused difficulty in the generalization of the results within graduate medical education.

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The researcher also had difficulty in how much time they could allocate to interview the study participants. As discussed in study design section in chapter four, the researcher felt that it was important to incorporate the perspectives of each study participant in an effort to capture personal narratives surrounding the use of simulation in a medical training program. Therefore, the researcher made the decision to utilize post-simulation interviews, as the researcher felt that a survey would not provide the same results from the study participants. However, most of the study participants were in clinical rotations that required them to be in the hospital, providing patient care during most of the business day. This resulted in the post-simulation interviews being short in length, as the researcher needed to be mindful of the trainees' time and getting them back to the wards. Additionally, as the study participants' Education Manager, the researcher wanted to be mindful of the boundaries of their professional role and not cause any potential tension between me and the trainees as a result of the research study. Therefore, the researcher did not feel comfortable professionally interviewing the participants after business hours.

Implications

The results of this study indicate the amount of prior exposure a trainee has to the medical competency that is being addressed in the simulation seems to have an influence on how the trainee perceives the value of the training. First-year participants had minimal amounts of exposure to the management of a patient with cardiogenic shock through the use of hemodynamics in the clinical setting prior to the simulation. They continued to not have much exposure to patients with cardiogenic shock and the use of hemodynamics after the simulation as first-year trainees are not scheduled in

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the cardiovascular intensive care unit within the first six months of their training. Study participants who were in their second year in the training program, rotated in the cardiovascular intensive care unit only once before the simulation session. As a result, it may have been difficult for these trainees to identify the hemodynamics of cardiogenic shock simulation as impactful as they did not have a clear sense of why it was important for them to learn how to identify and manage a patient with cardiogenic shock through the use of hemodynamics in the clinical setting.

The results of this study also indicate the amount of interaction that a rater has with the trainee may cultivate a bias in how they evaluate the trainee's procedural and theoretical knowledge. In examining each raters' average scores, the overall score report showed that the Nurse Practitioner rated study participants with a higher stringency than the Rotation Director and Cardiovascular Medicine Program Director. As discussed in chapter four, the Nurse Practitioner stated that her expectations of the fellows may have caused her to score the study participants with more scrutiny (Nurse Practitioner, personal communication, January 19, 2018). Moreover, the Nurse Practitioners' contact with the study participants is often limited to her interaction with the trainees when scheduled in the unit. The Program Director and Rotation Director have increased interactions with the study participants per the demands of their roles (fellow check-in) and as supervising attendees in the weekly fellow's clinic. Therefore, the results of this study indicate the possibility that the amount of interaction that the raters had with the study participants may have influenced their scoring of the trainees during the hemodynamics of cardiogenic shock simulation.

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Recommendations

Current ACGME requirements for Internal Medicine (IM) programs state that while simulation and skills facilities must be available for all trainees, an IM program may use simulation and skills laboratories in any manner they believe adequate to the competency goals of their educational program (ACGME Internal Medicine Program Requirements, 2013). In examining the results of this research study, in conjunction to the current research on simulation-based medical education, there was no consensus in volume and scope in how graduate medical education programs incorporate simulation training into their curriculum. While medical education has placed an increased reliance on simulation technology in the last two decades to boost the growth of trainee knowledge, provide opportunities controlled and safe practice, and shape the acquisition of clinical skills (Fincher & Lewis, 2002; Gaba, 2000; Issenberg et al., 1999), the ACGME needs to establish a simulation curriculum and make recommendations on how to incorporate simulation-based training in graduate medical education programs. Through the establishment of a simulation training curriculum, GME programs could provide a cohesive implementation of simulation within their programs, with the goal to enhance trainee learning. The implementation of a cohesive simulation curriculum could also serve as another program evaluation method to address any procedural and cognitive areas earlier in a learners' training, before they enter the clinical setting.

In addition to establishing a simulation curriculum, trainees need adequate exposure to simulations that are meaningful, practical, and relevant to their training in order for those simulations to enhance their learning. Kolb (1984), asserts that learning

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is not so much the acquisition or transmission of content as it is the interaction between content and experience, whereby each transforms each other. As addressed, the current ACGME Program Requirements for Internal Medicine (IM) Programs (2013), state an IM program may use simulation and skills laboratories in any manner they believe adequate to the competency goals of their educational program (ACGME Common Program Requirements, 2013). This resulted in GME programs incorporating simulation trainings in ways that were not viewed as meaningful or impactful to many of the study participants. The goal of a simulation learning scenario should be to provide adult learners with an opportunity to foster connections between experience and prior knowledge and new knowledge (Kolb, 1984). Providing GME trainees with an opportunity for learning that is both immersive and experiential through meaningful simulation training is critical to their learning experience. Therefore, tailoring the simulation to the learning level of the graduate medical trainees by training year could aid in providing the trainees with an environment that can foster self-awareness in their current theoretical and procedural knowledge, while cultivating critical thinking in a safe learning space.

Future Research

Future research might examine trainee perceptions of simulation-based medical training before and after a simulation session. A future study could examine the value that trainees place on simulation training prior to the session and the impact that the simulation had on trainees' values after the simulation. As addressed in the conclusion section of this chapter, for trainees to consider a simulation-based learning experience to be impactful, they need to determine the value that simulation has on

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their current clinical practice. Without direct clinical value, the simulation is often viewed as a non-impactful learning experience.

Another area of future research could explore graduate medical education trainees' language as an area of assessment. The assessment of a medical trainees' language function during the debriefing period of simulation-based training could provide a deeper understanding of how the trainee assigns meaning to concepts through their language. Language function is described as a representation of thinking, problem-solving and planning in alignment with social and cultural norms (Arwood, 2011). When meaning is given to what a person says or writes, then that meaning increases the concepts for higher cognitive development and the social use of language (Arwood, 2011). Concurrently, by understanding how language reflects a student's level of thinking or cognition, faculty members can customize feedback to help a student learn (Arwood & Kaakinen, 2009).

The theoretical framework that can be utilized to examine a trainee's language is the Simulation Based on Language Learning (SIMBaLL) Model that evolved from Arwood's (1991), Neurosemantic Language Learning Theory (Arwood & Kaakinen, 2009). According to Arwood and Kaakinen (2009), the Simulation Based on Language and Learning model or SIMBaLL provides a hierarchical framework to assess and measure conceptual learning outcomes within the parameters of medical education. Since concepts are acquired neurobiologically (Arwood & Kaakinen, 2009), the Simulation Based on Language Learning (SIMBaLL) Model uses a knowledge base grounded in neurobiological learning systems theory and not learning styles.

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Learning systems represent what happens in the central nervous system when a person learns a new concept (Arwood & Kaakinen, 2009). Learning styles refer to ways individuals believe they learn best (Arwood & Kaakinen, 2009). Additionally, learning styles are based on observable data that a person may be educated into believing; however, styles may not match what is happening in the learning system of the brain (Arwood & Kaakinen, 2009). The SIMBaLL model uses what is known about the learning system process of acquiring concepts (Arwood & Kaakinen, 2009). Furthermore, concept acquisition increases in complexity; therefore, the complexity of concept acquisition is parallel to developmental cognitive stages (e.g., Piaget, 1971; Vygotsky, 1934/1962).

Consequently, the language a student uses during simulation-based medical training can demonstrates a student's cognitive developmental stage of higher order thinking (Arwood & Kaakinen, 2009). According to Arwood and Kaakinen (2009), learning is both a social and a cognitive function of the learning system. Socially, how students respond to others as well as how they use language determines their cognitive level (Arwood & Kaakinen, 2009). Grading the student, on what the student understands or knows, is therefore based on the student's words and acts that demonstrate socially and cognitively how well the student is learning concepts (Arwood & Kaakinen, 2009). In this way, the student learns to construct meaning (Cooper & Kiger, 2003) and become literate in a given content area.

Closing Remarks

Graduate medical education integrates knowledge, skills, behaviors, and attitudes in developing a trainees' ability to care for patients. While assessment is a

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fundamental process to assure that learning has occurred, it is critical to determine gaps in a medical trainees' procedural and theoretical knowledge prior to entering the clinical setting. Failure to recognize gaps in knowledge or skill can lead to potentially fatal errors for patients. The implementation of simulation-based medical training can serve as an innovative tool to improve critical thinking and medical competencies among trainees in graduate medical training programs. Moreover, simulation-based training may be one of the better tools to determine a trainees' ability to integrate knowledge and expertise to solve patient problems and achieve safe and effective patient care, in a controlled setting.

For trainees to value a simulation-based learning experience, they need to understand the impact of that learning experience. Through the establishment of an ACGME simulation-based medical education curriculum, GME programs could provide a cohesive implementation of simulation with the goal to enhance trainee learning. In addition to establishing a simulation curriculum, providing trainees with adequate exposure to simulation that is meaningful, practical, and relevant to their training to elevate the trainee's overall learning experience. Therefore, the establishment of simulation-based trainings that are robust in medical competency, that are transparent in its objectives, and that are relevant to a trainees' current practice, will cultivate a meaningful and impactful learning experience for all medical trainees.

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Appendix A: Participant Consent Form

I. **<u>TITLE</u>**: Evaluation of Simulation-Based Hemodynamics of Cardiogenic Shock Education

II. **<u>PRINCIPAL INVESTIGATOR</u>**: Program Director

III. **<u>Co- PRINCIPAL INVESTIGATOR</u>**: Rotation Director

IV. **<u>PURPOSE</u>**: You have been invited to be in this research study while participating in your fellowship program. The purpose of this study is to assess the impact of a novel simulation-based method of hemodynamics education on the skills, knowledge, and competency regarding the physiology of acute cardiovascular collapse and invasive assessment of, and action upon, specified hemodynamics.

V. **<u>PROCEDURES</u>**: After providing your consent, you will be asked to complete a quiz to assess your baseline knowledge of out of hospital cardiac arrest and hemodynamic assessment and management. Following completion of the assessment, you will receive a didactic lecture on hemodynamics and cardiovascular collapse and undergo immediate simulation training, Participants will undergo written post-test to assess immediate acquisition of knowledge and skills and will be assessed by an observer and graded on a multipoint checklist in terms of observed awareness, skills and competency in a simulation setting. After 2-4 weeks, an interview may be conducted to determine retention of knowledge and skills in both groups.

If requested, you may have access to your personal scores from assessments. If you have any questions, concerns, or complaints regarding this study now or in the future, or you think you may have been injured or harmed by the study, contact the Principal Investigator of the study.

VI. **<u>RISKS</u>**: Although we have made every effort to protect your identity, there is a minimal risk of loss of confidentiality. Some of the survey questions may seem personal or embarrassing. You may refuse to answer any of the questions that you do not wish to answer. We mostly want to collect data on years of training, prior education on mechanical ventilation, and your comfort in managing mechanically ventilated patients.

VII. **<u>BENEFITS</u>**: You may or may not benefit from being in this study, although we anticipate that participation will increase comfort and skills in delivering mechanical ventilation. By serving as a subject, you will help us learn how to better educate future trainees on the principles of mechanical ventilation.

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VIII. **CONFIDENTIALITY:** In this study, we are not receiving any identifiable information about you so there is little chance of breach of confidentiality. You will assign yourself a 6-digit code you will use to complete all online surveys and assessments. Only the principle investigator will have a list of the codes (primarily in case participants forget theirs), and this will be kept on a secure X: drive behind the university firewall. The investigators and study staff may use the information we collect and create to conduct and oversee this research study, and store for future research purposes as well.

X. **COSTS**: It will not cost you anything to participate in this study.

XI. **PARTICIPATION:** This research is being overseen by an Institutional Review Board ("IRB"). You may talk to the IRB by phone or via email if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get more information or provide input about this research.

You may also submit a report to the university Integrity Hotline online or by calling toll-free (anonymous and available 24 hours a day, 7 days a week).

You do not have to join this or any research study. If you do join, and later change your mind, you may quit at any time. If you refuse to join or withdraw early from the study, there will be no penalty or loss of any benefits to that you are otherwise entitled.

The participation of university students or employees in university research is completely voluntary and you are free to choose not to serve as a research subject in this protocol for any reason. If you do elect to participate in this study, you may withdraw from the study at any time without affecting your relationship with the university, the investigator, the investigator's department, or your grade in any course. If you would like to report a concern regarding participation of university students or employees in university research, please call the university Integrity Hotline (toll free and anonymous).

By proceeding with unique identification selection and the survey, you are attesting that you have read this information.

____

Subject's Signature Date

____

Researcher's Signature Date

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Appendix B: Pre/Post-test

Scenario #1:
A 63-year-old male with history of COPD, tobacco abuse, diabetes, hyperlipidemia, presenting with out of hospital cardiac arrest. Upon arrival by EMS, he is found to be in ventricular fibrillation, and is successfully defibrillated, intubated, and transported to the Emergency Department.

Questions:

1. What, aside from vitals, is the first piece of data that needs to be gathered from the patient upon arrival to the ED?
    a. Family history
    b. 12 lead ECG
    c. Creatinine
    d. Down time and duration of CPR
    e. Urine output

2. Without ST elevation on his ECG, what compelling reason would he have to go straight to the cath lab?
    a. Mechanical Ventilation
    b. Widened mediastinum
    c. Widened pulse pressure
    d. Continued electrical instability
    e. Lactate of 12

3. Which of the following is NOT a poor prognostic marker in out of hospital cardiac arrest?
    a. Length of time for which CPR was performed
    b. Troponin elevation
    c. Lactate of 7
    d. pH less than 7.2
    e. No CPR performed

4. Due to a lack of ST elevation on his ECG, a decision is made to transport the patient to 12K CVICU for further management. You are called by the CVICU team 2 hours after arrival that the patient has not made any urine for the last two hours with a foley in place and is still not waking up. His heart rate is 123, blood pressure is 100/78(MAP 85), and SpO2 of 96% on 40% FiO2, PEEP of 8, sedated on a Propofol infusion. Please describe how you would assess his lack of urine output.

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5. Due to a lack of ST elevation on his ECG, a decision is made to transport the patient to 12K CVICU for further management. You are called by the CVICU team 2 hours after arrival that the patient has not made any urine for the last two hours with a foley in place and is still not waking up. His heart rate is 45, blood pressure is 85/63(MAP 70), and SpO2 of 90% on 70% FiO2, PEEP of 14, sedated on a Propofol infusion and dexmedetomidine. Please describe how you would assess his lack of urine output and any interventions you would make.

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Pre/Post-test Rubric

1. B – 1 point
2. D – 1 point
3. B – 1 point
4. Written response – 5 total points:
    - 1 point: Fellow recognizes that patient is in shock (this is rote – the fellows should have baseline knowledge that tells them immediately the patient is in shock)
    - 2-3 points: Fellow recognizes how to identify the cause of shock through the following (we are seeing a transition from rote to critical thinking):
        - His lack of urine output, in the setting of acute MI and OHCA, could be consistent with poor end organ perfusion
        - In this situation, differential diagnosis includes cardiogenic shock, hypovolemic shock, and hemorrhagic shock, Type A dissection, or obstructive shock (PE).
    - 4-5 points: Fellow then engages solely in critical thinking to describe steps followed to adjust the diagnosis- i.e. Lab findings of a normal hbg would eliminate hemorrhage, as well as no signs of bleeding on CT scan
        - The narrow pulse pressure suggests a small stroke volume, which could be secondary to hypovolemia or cardiogenic shock. To assess this, one would look at the JVD, or potentially the pulse wave variability on the arterial wave form.
        - Physical exam would be consistent with a cold and clammy patient, but this could be present in either hypovolemic or cardiogenic shock
        - An echo cardiogram demonstrating a depressed LV systolic function would favor cardiogenic shock
        - Determine the etiology of the shock, placement of a right heart catheter would give important data to analyze the intravascular volume status most effectively
5. Written response – 5 total points:
    - 1 point: Fellow determines the etiology of the shock, placement of a right heart catheter would give important data to analyze the intravascular volume status most effectively (based on pervious scenario – which should now be rote if assessed correctly)

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- 2-3 points: Fellow conducts the following (rote to critical thinking using previous fund of knowledge):
    - Describe chronotropic incompetence, whether from acute ischemic issues involving conduction,
    - Assess with an ECG to see if there was complete heart block or just bradycardia
    - Know that Propofol and dexmedetomidine are both profound negative inotropes and chronotropes, so they could be causing both hypotension in the form of vasodilation and negative inotropy
- 4-5 points: Fellows demonstrates their thought process for assessment of need for temporary pacing through the following:
    - Assessing if the cooling protocol has any negative impact on the chronotropy
    - Think about how a failing right ventricle could benefit from inotropy, as well as pulmonary vasodilation, and how increased intrathoracic pressure impedes the right ventricle even more
    - Assessed his hypoxia as low cardiac output

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Appendix C: AAC&U Critical Thinking VALUE Rubric

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CRITICAL THINKING VALUE RUBRIC

Association of American Colleges and Universities

	Capstone	Milestones		Benchmark
	4	3	2	1
Explanation of issues	Issue/problem to be considered critically is stated clearly and described comprehensively, delivering all relevant information necessary for full understanding.	Issue/problem to be considered critically is stated, described, and clarified so that understanding is not seriously impeded by omissions.	Issue/problem to be considered critically is stated but description leaves some terms undefined, ambiguities unexplored, boundaries undetermined, and/or backgrounds unknown.	Issue/problem to be considered critically is stated without clarification or description.
Evidence *Selecting and using information to investigate a point of view or conclusion*	Information is taken from source(s) with enough interpretation/evaluation to develop a comprehensive analysis or synthesis. Viewpoints of experts are questioned thoroughly.	Information is taken from source(s) with enough interpretation/evaluation to develop a coherent analysis or synthesis. Viewpoints of experts are subject to questioning.	Information is taken from source(s) with some interpretation/evaluation, but not enough to develop a coherent analysis or synthesis. Viewpoints of experts are taken as mostly fact, with little questioning.	Information is taken from source(s) without any interpretation/evaluation. Viewpoints of experts are taken as fact, without question.
Influence of context and assumptions	Thoroughly (systematically and methodically) analyzes own and others' assumptions and carefully evaluates the relevance of contexts when presenting a position.	Identifies own and others' assumptions and several relevant contexts when presenting a position.	Questions some assumptions. Identifies several relevant contexts when presenting a position. May be more aware of others' assumptions than one's own (or vice versa).	Shows an emerging awareness of present assumptions (sometimes labels assertions as assumptions). Begins to identify some contexts when presenting a position.
Student's position (perspective, thesis/hypothesis)	Specific position (perspective, thesis/hypothesis) is imaginative, taking into account the complexities of an issue. Limits of position (perspective, thesis/hypothesis) are acknowledged. Others' points of view are synthesized within position (perspective, thesis/hypothesis).	Specific position (perspective, thesis/hypothesis) takes into account the complexities of an issue. Others' points of view are acknowledged within position (perspective, thesis/hypothesis).	Specific position (perspective, thesis/hypothesis) acknowledges different sides of an issue.	Specific position (perspective, thesis/hypothesis) is stated, but is simplistic and obvious.
Conclusions and related outcomes (implications and consequences)	Conclusions and related outcomes (consequences and implications) are logical and reflect student's informed evaluation and ability to place evidence and perspectives discussed in priority order.	Conclusion is logically tied to a range of information, including opposing viewpoints; related outcomes (consequences and implications) are identified clearly.	Conclusion is logically tied to information (because information is chosen to fit the desired conclusion); some related outcomes (consequences and implications) are identified clearly.	Conclusion is inconsistently tied to some of the information discussed; related outcomes (consequences and implications) are oversimplified.

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