SIMULATION IN MEDICAL EDUCATION: A CASE STUDY EVALUATING THE

EFFICACY OF HIGH-FIDELITY PATIENT SIMULATION

Barbie Ann Klein

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Valerie Dean O'Loughlin, Ph.D., Chair

Doctoral Committee

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James Brokaw, Ph.D.

May 22, 2018

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Polly Husmann, Ph.D.

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James Cole, Ph.D.

DEDICATION

To my partner, David, and our pup Kaya "Piglet Petite," thank you two for supporting me throughout this journey. This work is also dedicated to my mom, Kim, for teaching me impeccable work ethic and academic diligence and to my dad, Mitchell, for keeping me positive and focused on the goal.

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EFFICACY OF HIGH-FIDELITY PATIENT SIMULATION

High-fidelity patient simulation (HFPS) recreates clinical scenarios by combining mock patients and realistic environments to prepare learners with practical experience to meet the demands of modern clinical practice while ensuring patient safety. This research investigated the efficacy of HFPS in medical education through a case study of the Indiana University Bloomington Interprofessional Simulation Center. The goal of this research was to understand the role of simulated learning for attaining clinical self-efficacy and how HFPS training impacts performance. Three research questions were addressed to investigate HFPS in medical education using a mixed methods study design. Clinical competence and self-efficacy were quantified among medical students at IUSM-Bloomington utilizing HFPS compared to two IUSM campuses that did not incorporate this instructional intervention. Clinical competence was measured as performance on the Objective Structured Clinical Examination (OSCE), while self-efficacy of medical students was measured through a validated questionnaire. Although the effect of HFPS on quantitative results was not definitive, general trends allude to the ability of HFPS to recalibrate learners' perceived and actual performance. Additionally, perceptual data regarding HFPS from both medical students and medical residents was analyzed. Qualitative results discovered the utility of HFPS for obtaining the clinical mental framework of a physician, fundamental psychomotor skills, and essential practice communicating and functioning as a healthcare team during interprofessional education

simulations. Continued studies of HFPS are necessary to fully elucidate the value of this

instructional adjunct, however positive outcomes of simulated learning on both medical

students and medical residents were discovered in this study contributing to the existing

HFPS literature.

Valerie Dean O'Loughlin, Ph.D., Chair

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LIST OF ABBREVIATIONS

CME: Continuing medical education

GME: Graduate medical education

HFPS: High-fidelity patient simulation

IPE: Interprofessional education

IUBIPSC: Indiana University Inter-Professional Simulation Center

IUSM-B: Indiana University School of Medicine, Bloomington

IUSM-E: Indiana University School of Medicine, Evansville

IUSM-FW: Indiana University School of Medicine, Fort Wayne

OSCE: Objective Structured Clinical Examination

QCA: Qualitative Content Analysis

SAET: Simulation-augmented education and training

SBET: Simulation-based education and training

SBME: Simulation-based medical education

SP: Standardized Patient

UME: Undergraduate medical education

VR: Virtual reality

CHAPTER 1: INTRODUCTION

With rapid advancements in medical knowledge and increased concern for patient safety, the need for competent healthcare professionals is paramount. Simulated clinical experiences are increasingly being incorporated into medical education to safely train future physicians in an early stage of their medical careers. **High-fidelity patient simulation (HFPS)** is one form of simulation utilized in medical education and is claimed to impart clinical competence (Scalese, Obeso, & Issenberg, 2007) by incorporating mock patients (in the form of trained actors or plastic manikins) and immersive environments (in which physical surroundings are recreated) for efficient acquisition of clinical knowledge and skills without compromising patient safety (Morgan, Cleave-Hogg, Desousa, & Lam-McCulloch, 2016).

In the United States, medical students typically spend four years in undergraduate medical education (UME) before continuing on to a specialized residency training program (which is part of GME, or graduate medical education). A traditional UME curriculum usually consists of basic science coursework in the first two years, including courses in gross anatomy, human embryology, histology (microscopic anatomy), neuroscience, and biochemistry, among other courses. Thereafter, the next two years of the medical curriculum are devoted to more practical clinical experiences and independent study.

However, this traditional curricular model has been deconstructed in recent years given calls to modernized medical curricula (Drake 1998; Drake, 2014; McBride & Drake, 2018; Mehta, Hull, Young, & Stoller, 2013; Prober & Khan, 2013). Modern

curricula are now combining previously independent subjects to create consolidated courses where basic science theory and clinical applications are taught concurrently (Brauer & Ferguson, 2014; Eisenstein et al., 2014; Irby, Cooke, & O'Brien, 2010; LCME, 2017). This process of amalgamation is known as 'curricular integration,' and is seen as medical schools across the United States transition to competency-based curricula (Frank et al., 2010). For instance, Indiana University School of Medicine (IUSM) recently underwent curricular reform across all nine campuses (see Chapter 3 for an explanation of IUSM). As previously described, this curricular reform consisted of combining several independent courses (e.g., 'Gross Human Anatomy' and 'Cell Biology and Histology') into a single course (e.g., 'Human Structure'). The new integrated Human Structure course focuses on teaching various anatomical disciplines through blocks of body systems (e.g., "Respiratory Unit").

With the intent of bridging the gap between theory and practice, the integrated medical curriculum model is thought to promote retention of basic and applied sciences by deliberately revisiting concepts (Finnerty et al., 2010), and commonly incorporates simulated clinical encounters. Note that many authors (Coombs et al., 2017; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Ziv, Wolpe, Small, & Glick, 2003) simply call any aspect of simulation used for medical training as **simulation-based medical education (SBME).** However, Haji and colleagues (2014) argued that this label does not accurately define current trends in simulation research, and thus described two approaches to simulation in healthcare training (including medical education, but not specific to medical education): **simulation-based education and training (SBET)** and **simulation-**

augmented education and training (SAET). The difference between SBET and SAET reside in the level of integration of simulation into other aspects of the curriculum.

SBET is an experience that is entirely contained with an immersive simulation context; for example, if a study focuses on the efficacy of only simulation, unrelated to other aspects of a curriculum, then the study is completely contained within the simulation context and is thus clarifying instructional design principles of simulation that does not extend into the other aspects of the curriculum. However, if a study's focus is simulation in relation to the larger curriculum, then simulation is augmenting existing education and thus the study's focus would be on how best to incorporate simulation to supplement the existing curriculum. SAET includes HFPS and aligns with the goals of integrated medical curricula by providing learners with an experiential activity to apply and enrich basic science knowledge on their path toward medical competency (Morgan & Cleave-Hogg, 2002).

HFPS is typically seen in graduate medical education (GME) and continuing medical education (CME); however, as medical schools increasingly migrate to integrated curriculum models, the use of HFPS is becoming more prevalent in UME. Scalese et al. (2007) noted that medical simulations generally, "aim to imitate real patients, anatomic regions, or clinical tasks, and/or to mirror the real-life circumstances in which medical services are rendered" (p. 46). HFPS has been described as an active learning strategy (Sheakley et al., 2016) which incorporates interprofessional team-based training (Bradley, 2006), provides a safe environment for skill acquisition (Henneman, Cunningham, Roche, & Curnin, 2007), is standardized for repeated practice and

performance-based assessment (Morgan & Cleave-Hogg, 2002), and is designed to balance action with reflective practice (Dotger, Dotger, & Maher, 2010).

The proliferative increase of incorporating simulation into curricula stems from the inherent interest in patient safety. Simulation not only teaches basic clinical and diagnostic skills but also provides for the assessment of human performance (Cooper & Taqueti, 2004). In 1999, Kohn, Corrigan, and Donaldson published a report entitled *To Err is Human: Building a Safer Health System*. The authors explained how medical advancements have led to increased complexity and the potential for diminished quality of care, harmful mistakes, avoidable injuries, and fatalities. At the time of the report, they noted that preventable deaths due to medical errors within hospitals exceeded the number attributed to the eighth-leading cause of death and was greater than deaths from motor vehicle accidents, breast cancer, or HIV/AIDS. They identified several factors that would systematically build intrinsic checks and safety processes throughout the healthcare system, one of which was the incorporation of simulations into healthcare education. The authors argued that meaningful feedback and reinforcement received during simulation improves team training and develops the necessary skills for learning to respond efficiently, effectively, and in a coordinated manner. The report concluded that simulators are tools for safety within healthcare education to combat erroneous human behavior.

Definitions of Terms Pertinent to this Research

Since the meaning of 'simulation' varies widely across the literature and among different professions, a strict definition was imposed for this study. The following definition of HFPS was used for this research and was adapted from Cooper and Taqueti

(2004), Fritz, Gray, and Flanagan (2008), and Maran and Galvin (2003): **High-fidelity patient simulation (HFPS)** is an authentic, immersive environment, incorporating advanced technology (e.g., interactive manikins) that responds realistically and appropriately to various stimuli, is integrated into the context of the curriculum (e.g., regularly utilized and includes an evaluation component), and ultimately, provides practical experience with the intention of improved patient safety for future clinical encounters.

This dissertation research investigated how HFPS influences competent behavior in developing physicians. **Competence** is considered an indicator of successful functioning in a particular role (Parnell, 1978). The Indiana Initiative (1996), drafted by Indiana University School of Medicine (IUSM), explains that a competency-based curriculum emphasizes accountability through outcomes that learners should accomplish by the end of their training. The report noted the increasing trend of national medical licensing organizations to adopt competency-based, criterion-referenced assessments and explained that when competencies are used as assessments, expectations are made explicit and formative feedback leads toward the ultimate goal of the institution, which is, "the preparation of scientifically competent, ethical, and humane physicians" (p. 31). Several competencies outlined by IUSM are achieved when utilizing HFPS, such as Basic Clinical Skills (Competency II) as well as Professionalism and Role Recognition (Competency IX). HFPS also meets competency standards outlined in the Liaison Committee on Medical Education (LCME) Standards for Accreditation of Medical Education Programs (2016), including: critical judgment/problem-solving skills

(Standard 7.4), communication skills (Standard 7.8), and interprofessional collaborative skills (Standard 7.9).

In addition to improvement in competent behavior, simulation has also been praised for enhancing medical student self-efficacy. **Self-efficacy** is a concept that is defined as an individual's subjective judgment about their ability to successfully perform a specific task (Kaufman & Mann, 2010). Albert Bandura, an influential psychologist from Stanford University, has extensively researched the construct of self-efficacy and explained, "an efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977, p. 193). Exposure to simulated clinical experiences has been shown to lead to significant increases in self-efficacy because learners are exposed to repeated practice in realistic surroundings and receive constructive, immediate feedback in a non-threatening environment (Goldenberg, Andrusyszyn, & Iwasiw, 2005). Cultivating the ability to accurately appraise one's performance is essential to ameliorating deficiencies in knowledge (Regehr, Hodges, Tiberius, & Lofchy, 1996; Speechley, Weston, Dickie, & Orr, 1994; Westberg & Jason, 1994), fostering life-long learning (Stewart et al., 2000), and ultimately develops a more competent, safer practitioner (Baxter, Akhtar-Dandesh, Valaitis, Stanyon, & Sproul, 2009).

Throughout the literature, the terms 'self-efficacy' and 'confidence' have been used synonymously. Although related, these concepts have distinct and specific meanings. Self-efficacy is a construct that will influence choice of activity, amount of effort exerted, coping ability, and persistence in the face of obstacles or aversive experiences. Stronger perceived self-efficacy leads to more active efforts, perseverance,

and a strong belief in the ability to succeed (Bandura, 1977). **Confidence** is a nondescript term, rather than a construct, that refers to one's personal belief in themselves; however, the term does not specify directionality of the belief or outcome expectations (Bandura, 1997). For instance, a student can feel very confident that they will perform poorly on an examination. Through confirmatory factor analysis, Rodgers and colleagues (2014) discovered that self-efficacy and confidence are conceptually and empirically distinct. Additionally, self-efficacy and self-esteem represent different constructs; self-efficacy refers to perceived judgments of capability, whereas **self-esteem** refers to judgments of self-worth (Bandura, 1997, 2006). This dissertation research focuses solely on self-efficacy and not confidence or self-esteem.

Statement of the Problem

As noted in the previous section, experiencing simulation in medical education provides a medium for enhanced competence, improved self-efficacy, and allows for essential practice while maintaining patient safety. However, HFPS studies demonstrating positive effects of this intervention (Coombs et al., 2017; Grantcharov, Kristiansen, Bardram, Rosenberg, & Funch-Jensen, 2004; Hall, et al., 2016; Kneebone et al., 2005; Sheakley et al., 2016; Steadman et al., 2006; Weiler & Saleem, 2017) are shadowed by many that found no significant differences when incorporating HFPS compared to other instructional methods (Fero et al., 2010; Kardong-Edgren, Lungstrom, & Bendel, 2009; Levett-Jones, Lapkin, Hoffman, Arthur, & Roche, 2011; Liaw, Scherpbier, Rethans, & Klainin-Yobas, 2012; Nyssen, Larbuisson, Janssens, Pendeville,

& Mayne, 2002; Reinhardt, Mullins, De Blieck, & Schultz, 2012; White, Brannan, Long, & Kruszka, 2013).

Inconsistencies are also found between students' self-assessment of their ability and their supervising instructor's assessment of their ability (Arnold, Willoughby, & Calkins, 1985; Calhoun, Ten Haken, & Woolliscroft, 1990; Stuart, Goldstein, & Snope, 1980; Woolliscroft, Ten Haken, Smith, & Calhoun, 1993), and when student self-assessment is compared to actual performance as determined by objective assessments, such as standardized exams (Blanch-Hartigan, 2011; Minter, Gruppen, Napolitano, & Gauger, 2005). The importance of feedback is highlighted in both studies reporting over-confidence and under-confidence seen in learners that received poor or inconsistent feedback (Schwartz & Griffin, 1993), and increased confidence without corresponding increase in skills when no feedback is provided after clinical experiences (Marteau et al., 1991).

Additional inconsistencies arise with investigations into the frequency of performing tasks on actual performance and self-assessment of ability. The number of times a specific task is preformed has not been shown to lead to improved performance on the task in some studies (Châtenay et al., 1996; Jolly et al., 1996; McManus, Richards, Winder, & Sproston, 1998; Morgan & Cleave-Hogg, 2002; Panek & Harvey, 1984), while other investigations have found significant positive correlations between the frequency of performing skills and self-assessed ability (Fincher & Lewis, 1994; Morgan & Cleave-Hogg, 2002). Therefore, it remains unclear whether simply obtaining more practice performing a specific task is effective for improving performance or self-assessment of ability.

There is also little consensus differentiating self-efficacy (or confidence) from competence, and contradicting correlations between self-efficacy and competence are extensive throughout the literature. Some considered self-assessed confidence to be a direct measure of competence (Cohen & Cohen, 1990), while others used competence to imply confidence (Speechley et al., 1994), or simply used the two terms interchangeably (Elizabeth & Hughes, 1986). However, Stewart and colleagues (2000) cautioned about using the concepts of competence and confidence synonymously. In a study of recently graduated medical students (known as pre-registration house officers in the United Kingdom where this study was conducted), the researchers found that positive expressions of confidence were related to competence; however, negative expressions of confidence were more related to anxiety than perceived incompetence. They noted that overconfidence may allow individuals to undertake unfamiliar tasks that they are not adequately prepared for, may attempt tasks without evaluating the potential risks involved, or may continue a task even if initially unsuccessful. Conversely, those lacking confidence may be unable to work independently or may experience debilitating levels of anxiety (Stewart et al., 2000); these results describe a concept commonly cited in the literature as the "unskilled and unaware effect" or by the eponymous label of the "Dunning-Kruger effect."

Kruger and Dunning (1999) published a profound study in which they subjected 65 Cornell University undergraduate students from a variety of courses in psychology to four distinct examinations in humor, logical reasoning, and English grammar. Results alluded to some students overestimated their performance ability and lacked the

metacognitive awareness to perceive their miscalibrated incompetence. The concept of over-estimation and under-estimation of ability is further explored in Chapter 5.

However, healthcare professionals will encounter unfamiliar situations and must demonstrate proficient skills independently, even with minimal practice (Westberg & Jason, 1994). Fero and colleagues (2010) claimed that, "the ability of new graduates to think critically and intervene effectively is essential" (p. 2,183). In these situations, levels of confidence and previous experience have been noted to be fundamental (Stewart et al., 2000), but these feelings must be monitored and accurately evaluated with knowledge of current competence and weaknesses to avoid dire consequences to patients. HFPS is believed to provide the necessary practice to impart learners with experience leading to competence. Thus, continued research into the impact of experiencing simulations in medical education and the most effective use of this technology is crucial.

Research Purpose and Questions

The inconsistencies throughout the literature warrant further investigation into the interaction between simulation experience, clinical self-efficacy, and actual competence, and several authors advised for continued research in this area (Blanch-Hartigan, 2011; Châtenay et al., 1996; Cohen & Cohen, 1990; Harrell, Kearl, Reed, Grigsby, & Caudill, 1993; Jolly et al., 1996; Morgan & Cleave-Hogg, 2002). Additionally, Cooper and Taqueti (2004) noted a lack of empirical research demonstrating the effectiveness of simulation and the transfer of training to the clinical environment. Due to the complexity of investigating educational interventions, such as simulation, on human performance and behavior, Chen and colleagues (2016) advised for mixed methods approaches since,

"some elements of learning and practice are difficult to quantify" (p. 340). When discussing the advantages of combining quantitative and qualitative approaches, Grbich (2013) listed three benefits: 1. Clarifies and answers more questions from different perspectives; 2. Enhances the validity of findings; and 3. Increases the capacity to cross-check one data set against another.

Therefore, this dissertation research was purposefully designed as a mixed methods case study of the Indiana University Bloomington Inter-Professional Simulation Center (IUBIPSC) and aimed to investigate the impact of HFPS throughout medical training, from the first year of UME through medical residency training. Both quantitative and qualitative methodologies were employed to generate a thorough understanding of the role of simulated learning environments in attaining clinical self-efficacy and how this impacts performance. Results from this research intend to further refine questions and extend theories associated with HFPS when used as a tool to develop competent healthcare professionals. The overall goal of this study aimed to generate evidence-based recommendations for successfully incorporating HFPS into medical curricula. The conclusions derived from this research have the potential to inform medical communities of opportunities to efficiently and effectively incorporate HFPS into curricula to best meet the unique needs and preferences of learners in medical school.

The following research questions were examined in this dissertation exploring HFPS in medical education (hypotheses and rationales for the quantitative research questions can be found in Chapter 3):

1. What is the relationship between ratings of clinical self-efficacy and competence, as measured by scores on final performance-based

assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?

2. To what extent do simulation performance scores predict ratings of clinical self-efficacy and competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?

    2a. To what extent do simulation performance scores predict ratings of clinical self-efficacy among second-year medical students exposed to HFPS?

    2b. To what extent do simulation performance scores predict competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?

3. How do first-year, second-year, and third-year medical students and medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?

    3a. How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?

    3b. How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?

Dissertation Outline and Methodologies

To investigate the research questions, this project encompasses eight chapters: Chapter 1 has introduced the impetus for the research and Chapter 2 presents a detailed review of the literature surrounding simulation in healthcare education and training. Chapter 3 reiterates the research questions that formed the foundation for this dissertation investigation, the proposed hypotheses and rationales accompanying the quantitative research questions, as well as a meticulous description of the methodology employed to investigate each aforementioned research question.

A pilot study, presented in Chapter 4, was commenced prior to the main dissertation research that investigated second-year medical students' perceptions from the IUSM-Bloomington (IUSM-B) class of 2018. The research questions associated with this pilot study are presented in Chapter 4, were exploratory in nature, and informed the main dissertation research that is found in Chapters 5 through 8. Eleven interviews with second-year medical students were conducted for this pilot study to obtain a broad understanding of the medical student experience during HFPS within the IUBIPSC. The interview transcripts were analyzed using a qualitative method known as the **directed approach to qualitative content analysis (QCA)**, which is a technique used to condense large amounts of textual data into comprehensive thematic interpretations, and explained further in Chapter 3 and applied in Chapters 4 and 6.

Chapter 5 presents the quantitative analyses that investigated Research Questions 1 and 2. The quantitative tests conducted to investigate Research Question 1 included: independent samples t-tests, Pearson correlations, and a one-way analysis of covariance (ANCOVA). Independent samples t-tests were used to compare composite OSCE scores and average self-efficacy ratings for each class level (e.g., first-year medical students, second-year medical students, and third-year medical students) for both the intervention group exposed to HFPS and control cohorts who were not exposed to this educational intervention. Pearson correlations examined the relationship between average self-efficacy ratings and composite OSCE scores between the intervention and control groups. Lastly, the ANCOVA was used to test the combined and independent effects of average self-efficacy rating and group (intervention using HFPS and control not using HFPS) on

OSCE performance, measured as the composite OSCE score, for each medical class cohort.

Ordinary least squares (OLS) regression was utilized to investigate Research Question 2, and the results are also presented in Chapter 5. OLS regression analyses explored the influence of simulation performance on composite OSCE scores and simulation performance on average self-efficacy ratings for the second-year medical students from the IUSM-B intervention group. Simulation performance was measured as a composite HFPS score that all second-year medical students at the IUSM-B intervention campus received. The composite simulation score was entered into OLS regression models to determine the extent that participating in HFPS had on composite OSCE scores (OLS Regression Model 1) and the extent that participating in HFPS had on average self-efficacy ratings (OLS Regression Model 2).

It is important to note that a qualified statistician employed by Indiana University was consulted to determine the most appropriate tests to answer the research questions and the proceeding statistical analyses were considered to represent the best available methods (M. Frisby, personal communication, May 17, 2018). As detailed in Chapter 5, the sample size ultimately obtained was inadequate to produce accurate statistical interpretation; however, the consultant advised continuing with the original statistics plan. Therefore, all results from Research Question 1 and Research Question 2 must be interpreted with the caveat of the statistical tests being underpowered. More information regarding the choice of the tests and the reason to continue with them are presented in Chapter 5.

Chapter 6 and Chapter 7 present the qualitative facets of this dissertation work. Chapter 6 answers Research Question 3a focusing on medical students and presents the results from qualitatively analyzing interview transcripts using the directed approach to QCA. Chapter 7 presents the analysis of medical resident perceptions of HFPS who had been exposed to HFPS during their medical education using a qualitative approach known as Q-methodology, addressing Research Question 3b. **Q-methodology** is a research technique used to obtain first-person qualitative perceptions, known as 'viewpoints' in Q-methodology, through a quantitative inverted factor procedure (Watts & Stenner, 2012). These two chapters add qualitative data to the simulation literature by incorporating the perceptions of both medical students currently experiencing HFPS, and medical residents who are actively working in the healthcare field and thus can reflect on their HFPS experiences while in medical school in the context of their current careers.

Finally, Chapter 8 presents overall conclusions and research-based recommendations for incorporating simulation into medical education based on reflections on the data obtained from the three research questions. This chapter also outlines future directions for investigating SAET and discusses the limitations of this research. Conclusions drawn from this research intend to capture a realistic view of the influence that HFPS has throughout medical training and into real-world practice and aid in informing future directions for the cohesive integration of HFPS in medical education.

CHAPTER 2: REVIEW OF THE LITERATURE

From Latin *simulare*, the word **simulation** translates as "to pretend" or "to imitate," which is embodied in the simulation experience as learners are asked to suspend their disbelief while participating in a crafted scenario. A persistent theme in the simulation literature revolves around technological advancements that create authentic, interactive scenarios to aid learners in suspending their disbelief. Learners in many fields of study, from aeronautics to veterinary medicine, utilize simulation to prepare for real-world events using realistic scenarios to gain experience for the acquisition of knowledge and confidence. This chapter will focus solely on healthcare simulation, and will not go into detail about the use of simulation in other fields of study, except when specific research studies yield information about simulation that could be applied to the healthcare field. As this chapter reviewing the literature will discuss, simulation in healthcare education is expansive, complex, and occasionally contradictory.

This chapter is divided into seven parts. Part I provides a brief history of simulation in medical education; this discussion is continued into the era of modern simulators in Part II. Part III explores the concept of simulation fidelity and provides examples of low-fidelity, moderate-fidelity, and high-fidelity simulators. The benefits, challenges, and limitations of simulation are illustrated in Part IV, while Part V describes several learning theories associated with high-fidelity patient simulation (HFPS). The current research in clinical simulation is reviewed in Part VI; and Part VII concludes this chapter with a description of various methods to qualitatively investigate simulation in healthcare education.

Part I: A Brief History of Simulation in Medical Education

Although considered a relatively modern instructional intervention (Bradley, 2006), simulation in healthcare education actually has an extensive history leading up to the advanced computerized systems and virtual reality presently available. The history of simulation likely began in ancient Mesopotamia between the fourth and first millennia BCE (K. Kunkler, personal communication, May 4, 2018). During this time, temple priests in the Babylonian and Assyrian cultures used simulators for teaching that were described as, "simple models fashioned from sheep lungs and liver" (Kunkler, 2006, p. 203). One of the first recorded uses of clinical simulation dates back to 500 CE in the *Sushruta Samhita*, a Sanskrit text of medicine and surgery (Owen, 2016). This text described using natural materials as surgical simulation training devices (for instance, a piece of wood studded with holes was used to practice probing a wound) intended for practitioners to learn how to quickly perform techniques and maneuvers, since the advent of anesthesia was still hundreds of years away.

In the year 1023, patient simulators were used in China to teach and assess acupuncture skills. Life-sized hollow bronzed casts with inscribed channels and acupuncture points helped to standardize acupuncture training across the country (Owen, 2016). These basic simulators of the past continued to evolve over time to eventually incorporate the entire body and became an essential, pragmatic training tool for many professions. For example, Salomon Reisel, a German physician and author, developed a full-body simulator in 1688. Crafted from various materials, including wood, iron, leather, ivory, glass, and silk, this simulator included several organ systems and could mimic cardiovascular disorders. Heart and lung mechanics were replicated using leather

bags, wooden blood vessels were painted red or black to signify oxygenation, and the kidneys filtered water into a glass urinary bladder that automatically voided when full (Owen, 2016).

The 18th century brought the Enlightenment, an era permeated by intellectual thought and the desire for scientific knowledge (Morriss-Kay, 2008). The demand for increased knowledge of the human body yielded advancements in medical procedures; however, the established apprentice-based model of instruction was no longer capable of accommodating this demand (Rosen, 2008). Medical courses were soon introduced that used advanced physical devices (i.e., early simulators) with intricate hydraulic and early animatronic systems (Owen, 2016). These devices provided healthcare learners with experience and opportunities for repeated practice of skills that they may not have otherwise received prior to working with real patients.

The need for accurate anatomic simulators required artistry and various mediums were experimented with including wax, wood, and papier-mâché until plastic counterparts evolved. In the 1690's, G. G. Zumbo, a Sicilian artist, collaborated with a French surgeon to craft the first anatomical wax models in Bologna (Morriss-Kay, 2008). Around 1745, Anna Morandi Manzolini began extensively researching the anatomical sciences and collaborated with her husband, an anatomy lecturer, to craft aesthetically appealing and accurate wax models. Although her husband died in 1755, Manzolini continued her research becoming Professor of Anatomy at the Institute of Bologna in 1756 and her designs were considered the most technically advanced wax models seen at the time (Messbarger, 2001).

Built in 1775 under the director of anatomical sculptor, Felice Fontana, La Specola workshop became a notable museum for wax models based on human dissections (Morriss-Kay, 2008). By 1799, Fontana left his directorship and was commissioned by Napoleon Bonaparte to create a realistic wooden model for advancement of healthcare education, since wax models were relatively fragile, could not be dismantled, or extensively handled (due to melting of the wax). Unfortunately, the wooden model was expensive, laborious to craft, and the wood warped when exposed to humid environments, preventing the more than 3,000 pieces from properly fitting (Owen, 2016).

The limitations imposed by wax and wood models prompted the need for another medium. Jean François Améline, a surgeon and professor of medical anatomy, crafted a model in 1817 with a human skeleton as the foundation, layered detachable papier-mâché for muscles, and used colored yarn and silk thread for vasculature and nerves (Owen, 2016). Although this model was precise in execution, evolving mechanics paved the way for more sophisticated simulators.

Recognition of advanced anatomical simulators spread after the Chicago World's Fair in 1933 of an exhibit demonstrating a dynamic life-size model with a mechanical heart showing circulation through the four cardiac valves and a simplified digestive system demonstrating nutrient absorption. The educational impact of the device was apparent as fair attendees marveled at, "moving models of the developed human being show the finished physical machine in its internal action" (Official guide: book of the fair, 1933, p. 37).

As healthcare simulation expanded over time around the world, the terminology associated with simulation also evolved. The modern term "simulator" has only been used in English, French, German, and Italian beginning in the 20th century (Owen, 2016). Prior to this time period, several names across many languages were used to convey the idea of a device intended to emulate a clinical condition or body region (Table 2.1).

Table 2.1: The evolution of English terminology used in healthcare education for the word 'simulator' (Adapted from Owen, 2016)

Century	Nomenclature
16th century	Automaton
17th century	Statue
18th century	Contrivance, apparatus, artificial man, doll, machine, phantom, puppet
19th century	Mannequin, manikin, replica, android
20th century	Dummy, robot, simulator

A number of factors ushered in the era of modern simulation technology and established simulation as an essential component of healthcare education. Pressure from governing bodies and societal expectations provided a boost of support for incorporating simulation to advance the standards of the modern medical profession (Bradley, 2006). For instance, Abraham Flexner, an education scholar, reported on the state of medical education in America and Canada in an influential assessment (Flexner, 1910). Flexner advocated for the transition from the apprenticeship model of medical education to an academic model, in which physical and biological sciences form the foundation for clinical instruction (Finnerty et al., 2010). In the report, Flexner admonished schools for their lack of simulator use, stating, "the teaching is an uninstructive rehearsal of textbook or quiz-compend: one encounters surgery taught without patient, instrument, model, or

drawing; recitations in obstetrics without a manikin in sight, – often without one in the building" (Flexner, 1910, p. 124). The report also recommended that manikins should be used during training of preliminary clinical drills.

Part II: The Era of Modern Simulators in Medical Education

Technological advancements led to a new resurgence of sophisticated simulators, and Resusci-Anne® is considered one of the earliest created (Cooper & Taqueti, 2004). Developed in the early 1960's by a Norwegian plastic toy manufacturer, Asmund Laerdal, this simulator was used for practicing ventilation technique during cardiopulmonary resuscitation (CPR). Laerdal was inspired to craft Resusci-Anne after a tragic story of a young girl found dead floating within the River Seine in France around the late 1890's (Jones, Passos-Neto, & Braghiroli, 2015). Lacking computer components and limited in its functionality, Resusci-Anne® did have an airway capable of being obstructed and required trainees to realistically hyperextend the neck and tilt the chin to open the airway completely for sufficient inflation. Later iterations of the model included a coiled internal spring attached to the anterior thoracic wall, providing a more realistic simulation of cardiac chest compressions.

In 1967, Dr. Abrahamson, an engineer, and Dr. Judson, a physician, both from the University of Southern California School of Medicine, developed Sim One (Abrahamson, Denson, & Wolf, 1969; Fritz et al., 2008). This machine is documented as the first computer-controlled manikin capable of visible chest rise and fall during breathing, had synchronized heart beat and blood pressure, coordinated temporal and carotid pulses, movable jaw and eyes, and physiologically responded to four intravenously administered

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drugs and two gases through a mask or intubation tube. The simulator was primarily used

for teaching anesthesia residents endotracheal intubation without posing harm to patients,

and analysis of five medical residents using the simulator compared a control group of

five medical residents, demonstrated that those residents in the simulator group achieved

better performance ratings and required less trials to reach success in less time compared

to the control group (Abrahamson et al., 1969). However, widespread adoption of this

technology was limited due to the immense cost of the computer software required for its

production; the Sim One prototype was developed from a $272,000 grant issued during

that time by the United States Department of Education (Cooper & Taqueti, 2004).

As technology exponentially improved, simulated clinical experiences became

more functional and affordable. Modern simulation used in medical education

encompasses a variety of opportunities for students to obtain skills, practice team

communication, and master clinical competencies, and includes: Standardized Patients

(SPs) (Barrows, 1993; Bokken et al., 2010; Dotger et al., 2010), computer-based

simulation (Dawson, Cotin, Meglan, Shaffer, & Ferrell, 2000), virtual reality (Kaufman

& Bell, 1997), models and part-task trainers (Gordon et al., 1980), and moderate-fidelity

and high-fidelity simulators (Fritz et al., 2008). Each of these educational interventions is

described in detail in the next sections.

Standardized Patients (SPs)

Used to provide future professionals a context to practice communication and

diagnostic skills, **Standardized Patients (SPs)** are typically paid individuals carefully

trained and knowledgeable of the simulated context and the specific verbal and physical

triggers to accurately portray a patient (Barrows, 1993; Dotger et al., 2010). SPs are used to imitate the future healthcare environment as realistically as possible in order to engage medical education learners and enhance the suspension of disbelief while participating in the simulation (Bradley, 2006).

SPs are advantageous to learn from compared to real patients for several reasons. First, SPs are convenient as they can be utilized anytime of the day and at any location, such as a classroom, instead of real patients at a hospital or clinic. Students may experience multiple attempts at a scenario with SPs rather than the single encounter with a real patient. SPs can also modify their behavior to reflect how a patient would appear given some time between the initial consultation and treatment, thus allowing students to learn continuity of care in a reasonable amount of time compared to real life. Finally, SPs are more ethical tools to use in medical education, as they are not real patients with potentially sensitive medical conditions or emergency scenarios (Barrows, 1993).

As the name suggests, SPs provide a standardized medical problem repeated for each student; therefore, SPs are used as sources for medical teaching and assessment (Collins & Harden, 1998). Faculty can observe students interacting with an actual person to evaluate communication skills and physical examination procedures. For example, in a randomized mixed methods study of 163 first-year medical students at Maastricht Medical School in the Netherlands, Bokken and colleagues (2010) evaluated performance with real patients or SPs to determine the most effective instructional method. They discovered that students believed SPs provided specific, reliable feedback; however, SPs could not convey the authenticity afforded by real patients. The authors concluded that

the choice between using SPs and real patients depends on several factors, including the phase of the medical curriculum and goals of the clinical encounter.

However, like all simulated strategies, the use of SPs does present disadvantages. The reliability of SPs to create consistent scenarios and instruction among students has been questioned (Dotger et al., 2010). Time is required to train individuals to be high-quality SPs and the physical findings that students may observe is limited. Invasive or sensitive procedures are also unable to be replicated while using SPs (Collins & Harden, 1998). However, Barrows (1993) argues that SPs are not meant to replace real patients; rather, they are meant to provide practice to enhance the value while working with real patients.

Computer-based Systems

The era of computer-based simulators began when mathematical models were created in order to simulate the physiologic and pharmacologic effects of drugs used during anesthesia (Cooper & Taqueti, 2004). The interactive programming and sophisticated medical education concepts embedded in the computer-based programs enabled independent learning through repetition and feedback. For example, Dawson and colleagues (2000) described a complex computer-based cardiology catheter simulator that incorporated hand-eye coordination, three-dimensional anatomic displays, fluoroscopic controls, and hemodynamic monitoring parameters. Other computer-based simulators, such as SLEEPER and Anesthesia Simulator Recorder, have been targeted for anesthesia training and praised for their realism and affordability (Cooper & Taqueti, 2004; Maran & Glavin, 2003). In a computer-based simulation study, 383 pharmacists and pharmacy

students at the University of Western Australia were recruited to explore the long-term effectiveness of an online simulated anaphylaxis pharmacology module compared to lectures or no training (Salter, Vale, Sanfilippo, Loh, Clifford, 2014). Results showed that the online module significantly improved knowledge on the immediate posttest and retention tests three-months and seven-months after the initial training.

Although convenient, computer-based models lack experiential, kinesthetic elements that are fundamental for learning clinical skills requiring psychomotor proficiency and dexterity. Continued advancements have ushered in new methods for combining technology with experiential techniques using virtual reality and haptic systems, which are described next.

Virtual Reality and Haptic Systems

Kaufman and Bell (1997) explained that **virtual reality (VR)** is an extension of computer-based simulations that adds psychomotor skills. With the intent of accurately recreating a realistic scenario using vision, touch, and sound, VR simulators digitally emulate an environment and incorporate interactive user elements (Scalese et al., 2007). Procedural skills and tasks requiring fine motor control typically employ VR training and may include a **haptic system** (i.e., a system which combines physical manipulation with spatial orientation of VR) to replicate kinesthetic and tactile perception (Bradley, 2006). For example, haptic systems may include gloves containing small sensors used to practice endoscopic and laparoscopic skills for surgical interventions. Other haptic VR systems have been used for practicing complicated surgical interventions that require

dexterity and precision, such as catheter insertion, obtaining vascular access and biopsies, and for arthroscopic techniques (Cooper & Taqueti, 2004; Scalese et al., 2007).

Does training on these haptic VR simulators adequately transfer to real medical practice? Grantcharov and colleagues (2004) investigated the transferability of a virtual reality simulator designed to replicate the techniques used during minimally invasive laparoscopic cholecystectomy on psychomotor performance of surgeons during real operations. In their randomized trial, the researchers found a statistically significant improvement in performance (specifically, faster operations, less errors, and greater precision and technique) of surgeons exposed to the VR trainer while in the operating room compared to a control group who were not exposed to the VR trainer. Although the investigators noted that a limitation of their study included a small sample size (16 subjects total, eight in each group), they concluded that the VR simulator provided objective evidence of improvement and should be incorporated into surgical training programs.

Although useful for a variety of skills training, computer-based systems and VR still lack elements of reality and the dynamics of interacting in a modern healthcare team with all of its social complexities (Henneman et al., 2007). Therefore, more immersive environments have been developed to enhance the realism, or **fidelity**, of clinical simulated scenarios.

Part III: Simulation Fidelity in Medical Education

Although some claim that the technical features of simulation devices have little impact on research conclusions (McGaghie et al., 2010), others have stated that

advancements in simulation technology offer novel clinical applications for medical students that they may not otherwise experience without compromising patient safety (Sheakley et al., 2016). Within any discussion of simulation, the concept of **fidelity** will surface, however the consistency regarding the usage of this term varies among scholars.

According to Mowbray and colleagues (2003), "fidelity may be defined as the extent to which delivery of an intervention adheres to the protocol or program model originally developed" (p. 315). Baxter and colleagues (2009) distinguished three different levels of fidelity in healthcare education: 'low fidelity' (including computer-based simulators and models), 'medium fidelity' (such as isolated body parts for learning specific tasks), and 'high fidelity' (responsive, interactive full-body manikins that include full functionality of anatomic and physiologic processes).

However, this simplistic continuum is intensely debated within the medical HFPS literature as inaccurately representing the spectrum of fidelity. Fritz et al. (2008) explained that conventional low-, medium-, and high-fidelity terms simply describe the equipment, to which they add 'environmental fidelity' (describing the realism achieved from the physical environment) and 'psychological fidelity' (reflecting the degree to which a learner perceives the believability of the simulation). Beaubien and Baker (2004) also explained that the concept of fidelity is multidimensional and proposed a typology of simulation fidelity encompassing 'environmental fidelity,' 'equipment fidelity' (the degree to which the physical devices duplicate the real system), and 'psychological fidelity.' The authors argued that of the three, psychological fidelity is the most important for developing teamwork skills training. High-fidelity patient simulation (HFPS) contributes to enhanced psychological fidelity by immersing learners in technologically

sophisticated environments leading to a believable experience. Regardless of this contentious debate, physical simulators are conventionally classified from low to high fidelity, and each category will be further explored in the following sections.

Low-fidelity and Moderate-fidelity (Part-task) Trainers

Part-task trainers are three-dimensional models of body parts or regions that emulate functional anatomy for teaching and evaluating learners on specific, isolated psychomotor tasks. Examples of part-task trainers include plastic arms used to learn venipuncture and suturing skills (Scalese et al., 2007), adult task trainers for teaching endotracheal intubation (Coombs et al., 2017), specific trainers for sensitive procedures, such as pelvic and breast examinations (McGaghie et al., 2010), and UltraSim™, a part-task trainer for ultrasound training (Rosen, 2008). Although simplistic in their intention, part-task trainers provide important feedback to learners, for instance, auditory clicking noises indicate the correct compression depth and pressure during resuscitation on a CPR simulator (Bradley, 2006).

Advanced part-task trainers, such as Harvey® Cardiopulmonary Patient Simulator (see Figure 3.2) and Simulator-K, contain sophisticated cardiovascular systems designed for learning auscultation and common cardiac pathologies (Gordon et al., 1980; Takashina, Shimizu, & Katayama, 1997). Harvey® Cardiopulmonary Patient Simulator (referred to as Harvey® throughout this dissertation) was developed in 1968 by Dr. Gordon of the University of Miami Medical School (Cooper & Taqueti, 2004). Named after Dr. Gordon's cardiac mentor, the sophisticated manikin is one of the first modern part-task trainers and continues to be used in medical education today. Harvey® is

capable of simulating 27 cardiac conditions, has bilateral jugular venous and multiple arterial pulses, precordial impulses, and uses a sound transmission system for groups of learners to listen simultaneously to normal breathing, heart sounds, pulses, and murmurs. Harvey's® success led to the development of smaller and more portable cardiology patient simulators, such as Simulator K; however, more advanced simulators were developed that went beyond cardiopulmonary simulation to aid healthcare trainees in learning full-body patient care.

High-fidelity Patient Simulators

The need to adequately convey realistic clinical environments and situations is vital to suspend disbelief and maintain learner interest (Scalese et al., 2007). **High-fidelity simulators**, also known as 'integrated simulators,' combine a manikin with sophisticated computer control manipulation to realistically emulate various physical, physiologic, and pharmacological parameters (Bradley, 2006). High-fidelity simulators demonstrate accurate responses after administration of interventions allowing learners to observe immediate cause and effect.

Two advanced anesthesia simulators were developed independently in California by Dr. Gaba and colleagues and in Florida by Drs. Good and Gravenstein (Cooper & Taqueti, 2004). At Stanford Medical School in 1987, Gaba developed the Comprehensive Anesthesia Simulation Environment (CASE), which combined a computer-controlled "patient" complete with vital sign manipulation and placed within a genuine operating room filled with actual surgical equipment and supplies (Gaba & DeAnda, 1988). This marked the creation of **high-fidelity patient simulation (HFPS)**, in which learners were

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immersed in a realistic physical environment with responsive manikins that aims to increase the psychological fidelity of the scenario (Cooper & Taqueti, 2004; Maran & Glavin, 2003). At the University of Florida, Gainesville, Drs. Good and Gravenstein developed the Gainesville Anesthesia Simulator (GAS), a system specialized to replicate errors caused by anesthesia machines. This sophisticated system was novel because the quick distribution through the manikin's lungs allowed for automatic recognition of injected drugs.

SimMan® (see Figure 3.2) is an advanced, interactive machine first manufactured by Laerdal Medical Corporation (Stevangen, Norway) in the mid-1990s that emulates the anatomic and physiologic functioning of a patient (Cooper & Taqueti, 2004). The simulator includes a variety of sophisticated capabilities, including: blinking of the eyes, dilation and constriction of the pupils, visible secretions from the forehead, eyes, nose, and mouth, ability to auscultate different heart rhythms, lung sounds, and bowel sounds, unilateral and bilateral chest movements, vascular access, programmed recognition of pharmacological agents, and automatic vital sign adjustments to current status.

Given these technological advancements of plastic manikins, certain elements of a patient's signs or symptoms may still be compromised. The French word **moulage** translates to "casting" or "molding" and relates to the application of mock injuries to both SPs and manikins to enhance the realism of a patient scenario (Huffman, McNeil, Bismilla, & Lai, 2016). This art of crafting authenticity dates back to the ancient Egyptians (Stokes-Parish, Duvivier, & Jolly, 2017), and takes many forms today, including: red dye-soaked bandages to simulate lacerations; an open bottle of acetone to simulate the smell of diabetic ketoacidosis; costume makeup and paint to create bruises,

burns, and wounds; various recipes using petroleum jelly and baby powder for fluid

discharges; mixtures of cocoa powder, oatmeal, and broken Snickers® bars to simulate

diarrhea; and crushed cereal, oatmeal, dehydrated baby food, and water to create emesis.

However, excessive or inappropriate moulage may create contradictions that distract

from the learning experience; therefore, moulage must be applied consciously and

meticulously in order to enhance the psychological fidelity of the simulation.

High-fidelity patient simulators have extensive literature devoted to the validation

and assessment of their educational efficacy. Studies investigating learner interest,

conveyed realism, and construct and content validity have all demonstrated positive

impacts of simulation (Chopra et al., 1994; Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001;

Sica, Barron, Blum, Frenna, & Raemer, 1999). However, little research has investigated

the transferability of skills to real-world contexts and verifying improved patient

outcomes remains largely speculative (Blum et al., 2004; Bradley, 2006; Hunziker et al.,

2010). Regardless, Gaba (1992) noted that, "no industry in which human lives depend on

the skilled performance of responsible operators has waited for unequivocal proof of the

benefits of simulation before embracing it" (p. 494).

Various mediums of simulation technology enable learners to experience

simulated contexts; however, certain drawbacks about this technology are evident. The

next section, Part IV of this chapter, will discuss both advantages and the limitations

associated with HFPS, as this is the main focus of this dissertation research.

Part IV: Advantages and Limitations of Simulation in Medical Education

Healthcare education literature is replete with benefits imparted to learners, including medical students and nursing students, using simulation in their curricula. In a systematic review of the literature, Issenberg and colleagues (2005) discovered that the most effective uses of HFPS are feedback given to medical students, the opportunity for practice, the integration of course content, individualized learning, and simulator validity for effective learning. HFPS has been cited as enhancing knowledge acquisition, critical thinking (Lapkin, Levett-Jones, Bellchambers, & Fernandez, 2010; Laster, 2007), student confidence (Bantz, Dancer, Hodson-Carton, van Hove, 2007; Reilly & Spratt, 2007), and more global domains of affective, cognitive, and psychomotor abilities in healthcare professional students. Scalese and colleagues (2007) claimed that simulation complements curricular remodeling to competency and outcomes-based medical education. After a review of the literature by the author (Anderson, Aylor, & Leonard, 2008; Benner, 2004; Brauer & Ferguson, 2014; Châtenay et al., 1996; Coombs et al., 2017; Dotger et al., 2010; Feather, Carr, Reising, & Garletts, 2016; Fincher & Lewis, 1994; Finnerty et al., 2010; Gaba & DeAnda, 1988; Grantcharov et al., 2004; Green et al., 2009; Gorman et al., 2015; Helmreich & Davies, 1997; Henneman et al., 2007; Kohn et al., 1999; Liaw et al., 2012; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011; McManus, Richards, Winder, Sporston, & Vincent, 1993; Moores & Chang, 2009; Morgan & Cleave-Hogg, 2002; Morgan et al., 2016; Peña, 2010; Reising, Carr, Shea, & King, 2011; Scalese et al., 2007; Schwartz & Griffin, 1993; Sheakley et al., 2016; Steadman et al., 2006), the most cited benefits of simulation include: skill acquisition, exposure to a wide range of clinical cases, reflection during debriefing, enhanced

communication skills during interprofessional education (IPE), integration of basic science theory with clinical practice, and attainment of one's personal ability to succeed, or self-efficacy. Each of these areas will be discussed in more detail below.

Simulation Advantages

Advantage: Skill Acquisition and Repeated Practice for Improved Patient Safety

Patient safety is paramount in healthcare and the antiquated apprenticeship model of healthcare education and practice is ineffective and unethical in modern medicine. However, with increased outpatient procedures performed and shorter hospital stays, the number of patients available for medical education learning opportunities and practice is limited (McManus et al., 1993; Morgan et al., 2016; Scalese et al., 2007). Most importantly, HFPS provides opportunities for repeated practice on a manikin, which largely avoids the ethical concerns of practicing on real patients and potentially risking their safety.

Several studies have demonstrated the need for practice in medical training, finding significant positive correlations between the frequency of performing skills and self-assessed ability (Fincher & Lewis, 1994; Morgan & Cleave-Hogg, 2002). For instance, after conducting correlation and multiple regression analyses between medical student's confidence and their experiences in caring for patients within a primary care clerkship, Harrell and colleagues (1993) concluded that hands-on clinical experience was the most significant variable for developing self-confidence. Although Jolly and colleagues (1996) observed little to no correlation between clinical skills and OSCE performance among 152 first-year medical students, they did note that performing skills

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at least once conferred a measurable increase in objective measures of expertise, measured as highest mean score at an OSCE station. Furthermore, a meta-analysis spanning a decade of simulation research found practice with simulation to be superior to traditional medical education in the acquisition of specific procedural clinical skills (McGaghie et al., 2011). These skills included laparoscopy, improved responses to advanced cardiac life support situations, cardiac auscultation skills, and improved performance of invasive procedures such as hemodialysis catheter insertion, thoracentesis, and central venous catheter insertion.

Ethical concerns while using real patients or SPs to practice invasive techniques (e.g., endotracheal intubation) and sensitive tasks (e.g., pelvic examinations) are also avoided when students learn on simulators. Routine and complex skills can be efficiently acquired and safely mastered when using HFPS, allowing students to participate in repeated practice within a controlled environment (Grantcharov et al., 2004; Liaw et al., 2012). Simulation allows "future professionals to engage in and address common problems of practice while still under the care and guidance of the program of study" (Dotger et al., 2010, p. 138).

Advantage: Exposure to Novel and Emergency Cases

Due to the flexibility of designing a breadth of authentic simulated cases, healthcare professional students have opportunities for exposure to a wider variety of clinical conditions, pathologies, and situations (Dotger et al., 2010; Morgan et al., 2016; Scalese et al., 2007). They are also afforded opportunities to assess and manage

uncommon and emergent pathologies without diverting immense cognitive capacity to patient safety, as they would experience in a real clinical setting (Liaw et al., 2012).

The adaptability to transform an immersive simulation room or program a high-fidelity simulator enables a spectrum of learning scenarios. For instance, literature has documented simulated operating rooms for anesthesia training (Gaba & DeAnda, 1988), nursing students treating chest pain during a simulated motor vehicle accident (Henneman et al., 2007), medical students learning cardiovascular assessment and interventions (Sheakley et al., 2016), and educators learning communication skills during simulated teacher-parent conferences (Dotger et al., 2010). Incorporating simulated exercises into medical curricula is ideal to prepare students for a variety of future encounters, thus enabling them to think and act quickly during critical situations.

Advantage: Debriefing to Promote Reflective Practice

HFPS usually follows a format of a short pre-brief to orient the students to the simulation environment, followed by the simulation event, and concluding with a debriefing session (see Figure 3.3). The **debrief** is a semi-structured discussion where instructors can review specific behaviors, decisions, and problems that arose during the simulation; the discourse usually begins with what went well for the learners during the simulation followed by what can be improved for the future, capitalizing on reflective practice, which is defined and explained in Section V of this chapter.

Some argue that the debriefing process following a simulation is the most important aspect of the learning experience because it provides time for immediate, individualized feedback and reflection on approaches used during the simulation

(Henneman et al., 2007). In support of this statement, Moores and Chang (2009) explained that performance feedback allows learners to recalibrate their perceived self-efficacy level toward a more accurate self-assessment of ability. Anderson et al. (2008) concluded that an area of active research within simulation literature remains in the type and amount of quality feedback provided to learners.

Although accurate feedback has been shown to be essential to the learning process, reports of the negative effects of ill-structured feedback in computer-based instruction, clerkship performance, and HFPS, pose an educational disadvantage. Schwartz and Griffin (1993) cautioned that poor or inconsistent feedback may result in student overconfidence. Châtenay and colleagues (1996) discovered that low-quality feedback during surgical clerkships resulted in lower OSCE scores even though learners received a high volume of experience and concluded that, "periodic low quality feedback may be detrimental to student learning" (p. 371). Therefore, the debrief at the conclusion of HFPS does not necessarily provide benefits to healthcare students; rather, it is how the dialogue during the debrief is structured that imparts learners with quality feedback.

Steadman et al. (2006) compared HFPS to problem-based learning (PBL) to determine effectiveness of each method for teaching acute care assessment and management skills to 31 fourth-year medical students in a randomized controlled trial. The simulator for the HFPS group was programmed to portray dyspnea and the students interacted with the simulator in the scenario, while the PBL group was presented cases studies as worksheets or handouts. Retention of knowledge was assessed five days after the HFPS and PBL interventions on a unique dyspnea scenario by two blinded investigators using a standardized checklist. Comparison of the initial assessment before

the HFPS/PBL interventions between the two groups using a *t*-test did not reveal statistical significance; however, the HFPS group significantly outperformed the PBL group on the final assessment after the interventions. The authors concluded that the realistic patient environment and discussions during the debriefing following the HFPS were significantly more robust than those seen in the PBL scenarios because students were more engaged with the course content while using the interactive simulator.

Advantage: Interprofessional Education (IPE) for Improved Team Communication and Performance

Interprofessional education (IPE) is achieved when multiple healthcare specialties communicate and work together simultaneously as a team to practice and engage in learning (World Health Organization, 2010). HFPS provides a medium for different healthcare professions, such as medical students and nursing students, to interact while solving clinical scenarios. This opportunity allows students from different fields a chance to collaborate as a healthcare team, which they may not otherwise be able to experience until working with actual patients.

Improved coordination of patient care is crucial to the development of effective team-based practice (Kohn et al., 1999), and it has been noted that many problems occur at the interface between disciplines (Helmreich & Davies, 1997). Scalese et al. (2007) explained that, "simulation-based programs enhance not only the development and evaluation of individual skills, but also effective collaboration in teams and the building of a safety-oriented culture" (p. 47). Thus, HFPS has the potential to safely establish productive healthcare team dynamics, provides an opportunity for healthcare

professionals to learn their individual roles, and encourages development of efficient communication skills.

IPE for medical and nursing students is well documented (Feather et al., 2016; Reising et al., 2011; World Health Organization, 2010). For example, a qualitative study investigated team communication during an advanced cardiac life support (ACLS) scenario between a traditional roundtable group compared to a HFPS group of 41 senior Bachelor of Science in Nursing students and 19 second-year medical students at Indiana University, Bloomington (Reising et al., 2011). Two medical students and three to four nursing student teams were randomly assigned to either the traditional roundtable (no fidelity) group, which consisted of a facilitator to unfold the case, or assigned to the HFPS group consisting of a full-body simulator, monitoring equipment, and a facilitator. Debriefing for both groups was intentionally kept to a minimum to avoid confounding facilitator interaction. Survey analysis revealed that regardless of group, almost all students (98.3%) claimed they had a better sense of their role on the clinical team and that the experience helped their interprofessional communication (100%). Although the HFPS group indicated that the exercise was stressful, those in the HFPS group noted that the realism of the encounter aided them to obtain a better sense of timing during events and that they more clearly understood and assumed their roles to become a more effective team.

IPE is not only effective with HFPS, but also when using real patients. Using qualitative content analysis (QCA), Feather and colleagues (2016) analyzed focus group data from IPE teams consisting of third-year medical students and senior nursing students managing a real patient (under the supervision of a faculty member). The teams met

regularly with their patient over two semesters and developed a treatment plan, simulating what they will experience in their clinical years, but in a formative, psychologically safe context of the IPE project. Overall, the researchers found positive responses from the students and patients after the IPE project, although students expressed the need for additional training in motivational interviewing and coaching.

Advantage: Integration of Basic Science Content with Clinical Application

In his seminal work on medical education reform in the early 20th century, Flexner advised for an experimental approach to the study of basic sciences through laboratory work (Flexner, 1910). Finnerty and colleagues (2010) echoed this approach, explaining that basic clinical responsibilities of gathering patient information, logically reasoning through differentials, and making decisions requires a systematic method grounded in scientific experimentation. HFPS provides students this laboratory experience using realistic, practical applications of basic science concepts linked to clinical contexts.

Simulation, from HFPS to low-fidelity part-task trainers, is advantageous as medical schools transition toward integrated curricula, in which basic science courses and clinical content are taught concurrently and revisited frequently throughout the program. Finnerty and colleagues (2010) explained that the integrated medical curriculum model promotes retention and prepares students for the demands of residency by imparting them, "with enough command of the foundational sciences to construct reasonable diagnostic and therapeutic plans" (p. 353). Brauer and Ferguson (2014) noted that beginning students in integrated curricula are expected to understand basic science

content and connect that information to clinical scenarios, which may be difficult if they have little or no clinical exposure. They recommended, "linking basic science material to clinical problems, often through patient-based or case-based learning" (p. 314).

All types of simulation, when used in conjunction with basic science lectures, are effective because they help, "bridge the gap between basic science and clinical knowledge through the use of clinical application" (Sheakley et al., 2016, p. 5). Research has found students experienced heightened awareness for patient safety in real clinical settings after being exposed to simulation (Henneman et al., 2007). The immediate relevancy to the learner's future career while participating in simulations is thought to impart deeper learning. HFPS capitalizes on the benefits of patient-based learning, which is thought to help internalize information because it is relevant to medical students' personal goals and applies material to real-life problems, leading to what Kaufman and Mann (2010) refer to as "meaningful learning."

Cognizant of the need to teach foundational sciences concurrently with clinical sciences to promote long-term retention and transfer, Gorman and colleagues (2015) described an education model within their medical school using structured HFPS that integrated physiology and pharmacology throughout the first and second years. Although effectiveness of their model was not quantified, they did note that perceptions were overwhelmingly positive, students requested additional simulations, and comments mentioned that participating in the simulations helped them to think about treating patients holistically rather than focusing on discrete and diseased organ systems.

Coombs and colleagues (2017) described a novel approach integrating simulations into a noncadaveric first-year medical human anatomy course. They created a

series of five simulation-based modules to supplement the curriculum to demonstrate clinically relevant anatomic concepts and reinforce basic anatomical knowledge. Analysis of 81 pretest and posttest scores alluded to the efficacy of short-term knowledge retention and themes from open-ended questions of student perceptions indicated a positive sense of learner engagement and an appreciation for the interactive nature of the modules. The authors concluded that integrating simulation as an adjunct to basic science curricula engages students in an active learning strategy, "that lend themselves to understanding the clinical and translational relevance of basic science" (Coombs et al., 2017, p. 499).

Advantage: Improved Self-efficacy

As previously described in Chapter 1, **self-efficacy** is defined as an individual's subjective judgment about their ability to successfully perform a given task (Kaufman & Mann, 2010). This construct is complex and difficult to measure since it involves self-evaluation of an individual's intrinsic beliefs of ability (Bandura, 1997). Much of the literature investigating HFPS training on self-efficacy is found in nursing research (Fry, MacGregor, Hyland, Payne, & Chenoweth, 2015; Goldenberg et al., 2005; Kameg, Howard, Clochesy, Mitchell, & Suresky, 2010; Lee, Lee, Lee, & Bae, 2016; Leigh, 2008; Pike & O'Donnell, 2010; Roh, 2014). While there are some investigations into the realm of medical education (Stroben et al., 2016; Wright et al., 2006), this dissertation research will add to the limited scope currently available at the time of this study.

Within medical education research, Stroben et al. (2016) conducted a study in a university hospital in Berlin, Germany using Standardized Patients (SPs) and simulators (specific simulation manikins were not described) to simulate a night shift in the

emergency room (ER) with 30 sixth-year medical students (note that in Germany, five years of medical school are followed by the sixth and final year spent in hospital internships). The researchers discovered a statistically significant improvement in self-efficacy within these final-year medical students, even though this intervention was short (spanning a single night).

Simulation Limitations

Although a plethora of benefits and advantages associated with the practice of HFPS exist, certain drawbacks are evident. Literature focusing on simulation-based education has exponentially grown in the past three decades; however, the lack of robust methodology, abundance of descriptive articles, and limited generalizability provides scant evidence-based conclusions for its implementation (Bradley, 2006; Landeen et al., 2015; McGaghie et al., 2010). Liaw and colleagues (2012) also cited the lack of rigor and objective evaluation of simulation as an intervention, and since simulation encounters are often integrated into the fabric of the overall curriculum, Weller and colleagues (2012) argued that it is often difficult to quantify learning outcomes specifically from simulation. However, the two most widely published limitations for implementing HFPS is resource investment (i.e., time and cost) and negative transfer of training. Both of these challenges will be discussed next.

Limitation: Resource Investment Required to Implement HFPS

Expenditures, both financial and logistical, must be considered when implementing simulation (Dotger et al., 2010; Liaw et al., 2012). Providing successful simulated experiences requires organized resource coordination including: thorough

planning, integrated implementation into the curriculum, coordination of course content and schedules, time for thoughtful reflection, and commitment from all involved (Henneman et al., 2007). Successful simulations also require extensive coordination among basic science and clinical faculty to ensure appropriate challenge and scaffolding, without overwhelming learner confidence (Gorman et al., 2015). These requirements can be difficult due to scheduling conflicts, workload adjustments, and departmental barriers.

Significant initial cost (Issenberg et al., 1999) and ongoing funding after the initial investment are also required to maintain a simulation program, which includes the need for sustaining equipment and continued training of personnel (Landeen et al., 2015). In 2008, Fritz and colleagues estimated the initial startup costs associated with constructing a simulation laboratory, purchasing manikins, equipment, and supplies, installing audio-visual recording technology, budgeting for upgrades and maintenance, and training faculty and/or staff exceeds $1,160,500 AU ($883,633 US). The simulation center at Indiana University School of Medicine in Bloomington was constructed in 2012 and the investment was approximately $400,000 in renovations and $550,000 for equipment, supplies, and trained personnel (J. Watkins, personal communication, May 18, 2018). Regarding personnel, one full-time Simulation Coordinator was employed to manage all simulations within the IUBIPSC. At the time of this writing, this individual is on a 12-month contract through the IU School of Nursing for $72,068.

Even after expenditures for technical equipment, fidelity is still a challenge. For instance, psychological fidelity (defined earlier in this chapter as the degree to which a learner perceives the believability of the simulation) may be compromised. Learners may still struggle to view a plastic manikin, however technologically advanced it may be, to

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be a real patient. O'Regan and Coombs-Thorne (2017) confirmed this in their discussion of a physiology simulation scenario, concluding that the manikin does not "adequately address the interpersonal or inter-professional dynamics of the scenario" (p. 389).

Limitation: Negative Transfer of Training

Negative transfer of training is said to occur when students learn something incorrectly or are unable to apply what they have learned in a simulation to a real-world situation (Fritz et al., 2008). Reports on deficits in knowledge and competencies from training using simulators cite a lack of physical fidelity, or artificial acceleration of tasks intended to conserve time, as imprinting incorrect practices and improper skills. The complexity associated with HFPS also poses a risk of cognitive overload if not properly scaffolded. Therefore, Gorman and colleagues (2015) advised using simulations as an active learning strategy to reinforce previously taught material rather than introducing new information.

In a descriptive review of 23 experimental and quasi-experimental simulation studies of pre-licensure practitioners in nursing, medicine, and rehabilitation therapy, simulation training was found to be useful and led to high learner satisfaction; however, transfer to real-world practice remained unclear (Laschinger et al., 2008). The authors also commented that a threat to the utility of simulator technology resides in the potential for negative transfer of training if the simulation scenarios are imperfect or if the simulation lacks immediate feedback from clinical instructors.

Although these challenges exist when incorporating HFPS into a healthcare curriculum, students do learn during these encounters and this learning has been studied

and documented. The literature focusing on the learning theories surrounding the use of HFPS as an educational intervention will now be explored.

Part V: Learning Theories Associated with HFPS in Medical Education

The realistic context afforded by HFPS generates student enthusiasm, increases motivation, and improves effort (Laschinger et al., 2008). Due to these benefits, HFPS is incorporated into various healthcare domains, which leads to deeper understanding and long-term retention of knowledge (Kaufman & Mann, 2010). Several educational processes underpin the benefits of simulator training, including: experiential learning theory (Yardley, Teunissen, & Dornan, 2012), reflection (Maran & Glavin, 2003), and deliberate practice (Anderson et al., 2008). Each theory will now be further explored in the context of simulation-based training.

Experiential Learning Theory

Experiential learning theory (ELT) is a model posited by Kolb (1984) drawing on the influential work of John Dewey and Kurt Lewin (Kolb & Kolb, 2005) and explains that knowledge is constructed and meaning is created through authentic experience followed by reflection (Anderson et al., 2008; Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 2000; Yardley et al., 2012). ELT offers a multimodal approach to learning and is more likely to lead to deeper, meaningful learning; this is because students are actively engaged in deliberate practice assimilating information in the context in which it will be used. DiLullo (2015) exemplified this, stating, "experiential application of conceptualized knowledge supports the development of expertise" (p. 15).

Six principles form the foundation for ELT (Kolb, 1984; Kolb & Kolb, 2005):

1. Learning is best conceived of as a process rather than specific outcomes, and this process includes feedback;

2. Effective learning draws upon existing student beliefs and ideas and is grounded in their experiences;

3. Conflict, differences, and disagreement drive the learning process;

4. Learning is a holistic process of adapting to the world;

5. Learning is a continuous process of synergetic transactions between learners and their environment; and

6. ELT draws on constructivist theories of knowledge acquisition, in which personal knowledge is created through social interaction, active experimentation, and reflection.

HFPS provides a medium for attaining the six principles of ELT by immersing learners in authentic, realistic (i.e., high-fidelity) environments followed by a period of reflection during the debrief session. Anderson and colleagues (2008) related the ELT principles to HFPS by explaining that:

1. Simulation involves repetitive practice and feedback on learning efforts;

2. Learning with a simulator encourages students to identify their prior knowledge then build upon and refine that knowledge;

3. During simulations, learners must confront the differences that exist between novice and expert performance;

4. Learning during simulation is a holistic process involving management of affective emotions along with emerging perceptions during the course of the simulation; and

5. During simulated experiences, learners must independently discover new insight and problem solving.

Kolb and Kolb (2005) explained that higher education could implement ELT by creating learning environments that encourage reflection and, "that promote growth-producing experiences for learners" (p. 205). These growth-producing experiences also support transfer of knowledge among medical students as they are able to engage in scenarios that they will likely encounter during the future demands of their practice (Dornan, Scherpbier, & Boshuizen, 2009). Kolb and Kolb (2005) further explained that experience followed by reflection is key to the experiential learning process, and concrete experiences form the basis for reflection. The immersive environment of HFPS provides this concrete experience by engaging students in authentic, experiential practice. Since students do not have to imagine or mentally construct the environment, cognitive capacity is freed to efficiently work on the problem scenario.

Evidence and advocacy for the implementation of ELT for effective learning is prevalent in education literature, including HFPS literature. Cognitive developmental research supports immersive HFPS by explaining that, although learners have the capacity for abstract thought, certain benefits and opportunities are conveyed through physical manipulation and experimentation with concrete materials (Ormrod, 2012). Yardley and colleagues (2012) echoed this when stating, "experience gained in authentic workplaces that are concurrently involved in education and delivering real-life services is

the most important medium through which people learn to practice as healthcare professionals" (p. 161). Dornan and colleagues (2007) also found in their study examining experience-based workplace learning among medical students that students learned best through practice and the practice made them feel more confident. Finally, Anderson and colleagues (2008) stated that ELT experienced through simulation, "address the cognitive, technical, and behavioral domains of learning, resulting in deeper learning and better retention" (p. 598).

Some embodied cognition theorists explain that the mind is rooted in physical surroundings, bodily experience, and action (Garbarini & Adenzato, 2004). However, Eraut (1994) cautions that simply experiencing an event does not impart competence. He eloquently explained that reflecting on the event is the key to gaining expertise because, "each of us is embedded in a continuous flow of experience throughout our lives. Discrete experiences are distinguished from this flow and become meaningful when they are accorded attention and reflected upon. The 'act of attention' brings experiences, which would otherwise simply be lived through, into the area of conscious thought" (p. 104). Therefore, simulation without appropriate reflective practice may be an ineffective endeavor.

Reflective Practice

As stated previously, ELT posits that learners transform experiences through active experimentation and reflective observation. **Reflective practice**, also referred to as **reflective thinking** by Decker et al. (2013), is defined as, "the process of analyzing cognitive and affective aspects of experiences to gain understanding that will lead to

improved performance" (Anderson et al., 2008, p. 598). HFPS is effective for improving performance because this educational strategy fosters reflective thought processes (and thus, reflective practice) during the debrief.

Simulations typically conclude with a debriefing session, in which learners reflect on their experience with a supervising instructor. These sessions encourage learners to engage with facilitators while reflecting on their experiences, articulating their thought processes, and discover insights into their ability. Therefore, HFPS explicitly links an experiential activity (i.e., the simulation) with reflection (i.e., the debrief) for efficacious learning.

Henneman et al. (2007) argued that the discussion during the debrief is the most important aspect of the simulation because it affords time where instructors can immediately review specific behaviors, decisions, and issues and provide individualized feedback. Liaw and colleagues (2012) confirmed the benefits of debriefing in their randomized controlled study of nursing students exposed to simulation compared to a control group, explaining that the, "debriefing provided opportunities for expert feedback and self-reflection on performance" (p. 37). Westberg and Jason (1994) argued that when little attention is given in a medical program to foster learner's ability for reflection and self-assessment, they are at risk of becoming unsafe physicians. They explained that the debrief affords learners a valuable opportunity to relive and recall events that passed rapidly, so that learners can make their own insights and discoveries.

Feedback and reflection have been shown to improve trainee performance (Veloski, Boex, Grasberger, Evans, Wolfson, 2006) and decrease cognitive errors (Mamede, Schmidt, & Rikers, 2007). These examples of experience followed by

reflection illustrate how simulations can contribute to the experiential learning cycle (Maran 2003; Kolb, 1984).

Deliberate Practice

Clinical simulations provide a platform to instigate deliberate practice. Anderson and colleagues (2008) define **deliberate practice** as, "the individualized training activities designed to improve the current level of an individual's performance through repetition and successive refinement. The explicit goal is to improve performance" (p. 599). Ericsson (2004) noted that deliberate practice coupled with constructive feedback has been shown to lead to improved performance and the acquisition of expertise in medicine and related domains. Critical thinking skills acquired during simulator training "may result in greatest transfer of skill from the practice domain to the real domain" (Anderson et al., 2008, p. 599).

The learning theories manifested through diligent research over the last few decades and paved the way for widespread implementation of HFPS in healthcare education. However, active research continues to investigate the implementation, evaluation, and overall impact of HFPS as an instructional tool. Modern research methods and contemporary investigations of HFPS in medical, nursing, and undergraduate education will now be explored in the following section.

Part VI: Current Research in Medical Simulation

Research into the educational and behavioral impact of the short-term and long-term gains while using simulation (from low-fidelity task trainers to HFPS) is imperative

to efficiently and effectively incorporate this technology for student knowledge acquisition. Research in cognitive psychology explains that learners organize knowledge most efficiently when they experience it in the way in which it will be accessed and used (Ambrose et al., 2010). Therefore, it seems plausible that teaching healthcare professionals in the environmental context of their future careers will lead to enhanced retention.

Incorporation of HFPS into the curriculum has occurred over decades; however, rigorous methodological research focusing on the long-term effects of this technique is relatively new. Investigations into the immediate and short-term effects of simulation are extremely abundant in several fields of study, including healthcare professions and undergraduate majors, while medical and nursing populations dominate the literature on the long-term effects (which will be described and cited later in this section). The word 'long-term' also has various interpretations throughout the literature with articles reporting retention tests administered a few days after simulated interventions to several months or years later. Current research in medical, nursing, and undergraduate education will now be elucidated, respectively.

Current Research in Undergraduate Medical Education (UME) and Continuing Medical Education (CME)

Hall and colleagues (2016) conducted a study of knowledge retention of first-year medical students using Harvey® Cardiopulmonary Patient Simulator in addition to lecture compared to historical controls exposed to lecture alone. The authors reported that simulator training in addition to lecture led to a statistically significant improvement in

summative cardiovascular physiology exam scores compared to historical controls exposed only to lecture. The researchers concluded that although the technology proved beneficial, a longitudinal study was needed to determine long-term retention. In a similar study design using Harvey® Cardiopulmonary Patient Simulator in conjunction with lecture versus lecture alone, Sheakley and colleagues (2016) found significantly higher scores and passing rates on summative exam performance for an intervention group of 1,066 medical students (specific level of medical school that these students were in was not indicated) compared to a historical control group of 515 medical students given only a cardiovascular lecture.

While these immediate, short-term studies add value to the HFPS debate, a long-term retention study compared knowledge retained from HFPS compared to traditional lecturing in medical students (Alluri, Tsing, Lee, & Napolitano, 2016). Although this study found no statistically significant difference between the pretest and immediate posttest, the authors conducted a randomized control study with a five week delayed posttest of 20 second-year medical students and discovered that the simulator group had statistically significant knowledge retention compared to the lecture group on the delayed 5-week posttest.

In a retention study of 47 first-year internal medicine residents, intensive care unit (ICU) skills were retained one month after simulation training with a 15-minute standardized "booster" training session held prior to rotations (Moazed et al., 2013). Three weeks to up to one year after the booster session, study participants were evaluated at the bedside of actual ICU patients using a 20-item skills checklist that had previously undergone reliability and validity assessment. Residents scored a mean of 90% (*SD* =

6.5%) during the simulation and a comparable mean of 89% (*SD* = 8.9%) during the later bedside follow-up exam; those who participated in simulation also scored higher on the skills checklist compared to historical controls who lacked simulated training. The authors concluded that participating in a simulation led to substantial retention of critical care knowledge for up to one year.

Vadnais and colleagues (2012) showed that simulation was effective in teaching physicians management of life-threatening obstetric events (specifically: eclampsia, shoulder dystocia, postpartum hemorrhage, and vacuum-assisted vaginal delivery). A posttest of 35 multiple-choice questions was administered immediately after the simulation, again at four months, and at 12 months after the simulation. A survey with a 10-point Likert scale assessed self-perceived comfort level in managing the cases. Results indicated that simulation improved knowledge and confidence, which was maintained one year later.

Several retention studies in medical simulation literature have focused on psychomotor skill acquisition. Jiang and colleagues (2011) reported significantly improved thoracentesis skills at six months and at one year after exposure to simulation training compared to a control group without simulation. They noted saturation in improvement after four simulated practice sessions and concluded that over-training may not result in further gains in competence. Basheti (2014) published significantly higher findings of correct administration of three different types of inhalers by pharmacy students one week after a simulated scenario compared to a control group without simulation training. Finally, a slightly older longitudinal retention study of 92 third-year medical students found simulator training of basic procedural skills (e.g., needle

injections and suturing techniques) to be more efficacious in terms of self-assessed ability and instructor-rated competence two years after training compared to a historical control (Liddell, Davidson, Taub, & Whitecross, 2002).

These studies allude to the impact that HFPS has on knowledge retention throughout medical training, which is often difficult to quantify and limited in scope to a single intervention or short experience. There are several studies reporting perception data of medical residents toward HFPS as well (Deutsch 2008; Walsh, Garg, Ng, Goyal, & Grover, 2017); however, to the authors' knowledge, there are no studies that elicit perception data from residents regarding their HFPS experiences during their medical education. This dissertation research will add a unique perspective of those medical residents who experienced HFPS integrated into their medical curriculum, and have subsequently graduated. Thus, the medical residents included in this dissertation research can reflect on the impact of this instructional intervention in the context of their current careers.

This section focused on HFPS in UME and CME; however, much of the research into the short-term and long-term impact of simulator training is derived from literature on nursing students, which will be briefly explored in the next section.

Nursing Education

Long-term retention and transfer studies reported in undergraduate nursing education have found positive effects of low-fidelity and high-fidelity simulation training in respiratory pathophysiology after one week (Kirkman, 2013), CPR training after three months (Ackermann, 2009), and objective structured clinical examination (OSCE) scores

after six months (Alinier, Hunt, Gordon, & Harwood, 2006). Domuracki and colleagues (2009) reported on the ability for nurses, medical students, and nursing students to transfer knowledge and skills gained from a HFPS to a traditional clinical environment. Cricoid pressure is applied to patients to inhibit regurgitation during anesthesia intubation. The researchers measured cricoid pressure applied to anesthetized patients shortly after either receiving a verbal description of how to apply cricoid pressure or immediate feedback from a cricoid pressure part-task simulator. The simulator training significantly improved performance of the cricoid pressure technique resulting in effective and safe application in the actual clinical setting.

Kirkman (2013) conducted a study of 42 undergraduate nursing students in their ability to transfer knowledge and skills from a respiratory HFPS to a clinical setting. The researcher demonstrated a significant positive effect on transfer one week following simulator training. Alinier and colleagues (2006) reported on the statistically significant improvement on a 15-station objective structured clinical examination (OSCE) among 99 second-year undergraduate nursing students exposed to a simulation experience in their curriculum six months after the simulation compared to a control group whose curriculum did not include simulation.

Ackermann (2009) employed a repeated measures design using undergraduate nursing students to research whether standard American Heart Association (AHA) cardiopulmonary resuscitation (CPR) training with HFPS improved acquisition and retention of knowledge and skills compared to the training alone. The knowledge variable was measured through a 14-item multiple-choice test while the skills variable was measured from evaluations by the investigator of students' performance on a full-body

patient simulator using a standardized checklist. The simulation group was found to have statistically significant acquisition of both CPR knowledge and skills on the posttest immediately after the intervention. A retention examination three months after the training also showed the simulator group outperformed the control group on both knowledge and skills.

Undergraduate Education (pre-medical, pre-nursing, and allied health students)

Although medical and nursing student populations dominate simulation research, some simulation studies have focused on other student populations, such as undergraduate students (e.g., pre-medical, pre-nursing, and other allied healthcare students). For instance, pathophysiology simulations were introduced at an Australian university to second-year medical and biomedical science undergraduates to promote a deeper understanding of pathophysiology topics and support the development of affective attributes, such as communication, teamwork, leadership, and decision-making skills (Chen et al., 2016). The simulated scenarios were crafted to promote transfer and application of theoretical knowledge to clinical settings, provide opportunities to practice and reinforce concepts, and allow students to interact with each other in a team environment. Comparison of historical controls was used to evaluate the educational effectiveness of the curricular change. Overall course grades demonstrated a positive effect of the simulation intervention and qualitative analysis of survey data yielded comments about the helpfulness of the simulations and enjoyment with the experiences. Three main themes emerged from their data: the authenticity of the setting, the development of communication skills, and the support provided by the demonstrators.

Simulations (computer-based and HFPS) utilized in other undergraduate domains have also found improved long-term learning outcomes six months after a robotics course (Correll, Wing, & Coleman, 2013) and 18 months after a physics course (Dori, Hult, Breslow, & Belcher, 2007). Simulation-based laboratories were incorporated into a one-year undergraduate introductory robotics course with content knowledge and subjective perception measured before, immediately after, and six months after the course (Correll, et al., 2013). Similar to that seen in the medical field, the robotics course employed performance-based assessments of competence as the final course examination. The researchers found content knowledge and subjective perception of confidence remained above the "before" course levels six months after the conclusion of the course.

An introductory physics class of almost 600 students at MIT employed a collaborative, hands-on learning environment where students carried out simulated electromagnetic experiments (Dori et al., 2007). From their longitudinal study of posttests and retention tests, the researchers found that the group experiencing simulation outperformed a control group receiving traditional lecture recitations in conceptual understanding one year to 18 months after completion of the course. Content analysis of student attitudes from surveys and focus groups revealed that the simulated format contributed to their learning. The researchers concluded that the long-term impact of this simulator technology was beneficial to undergraduate populations. Harris and colleagues (2014) described cardiovascular and pulmonary HFPS interventions with 18 undergraduate biomedical students using a repeated measures design. Paired t-tests demonstrated significant improvement in posttest scores and analysis of validated survey questions revealed students recognized the importance of communication and teamwork.

Many of these studies relied heavily on quantitative methods of evaluation, including correlations, factor analyses, assessment between group means (e.g., *t*-tests), and regression analyses. However, statistical quantification can only provide so much information given the intricate and dynamic nature of education. Therefore, qualitative methods must be employed to fully articulate the complexity of pedagogical interventions, such as what this dissertation research has done and described completely in the following chapters. To more deeply understand the impact of HFPS in medical education for this research, the specific qualitative methodology that was employed for this research will now be discussed in more detail.

Part VII: A Spectrum of Qualitative Research

Cleland (2017) defines qualitative research as an investigation into "how the social world is interpreted, understood, experienced, or constructed" (p. 62). This approach to data collection, analysis, and interpretation provides detailed information about individual experiences and insight into attitudes and behaviors when little to no data exists of the area (Grbich, 2013). The goal of qualitative research is usually not to test what is already known, such as theories formulated in advance as seen in quantitative approaches. Rather, qualitative research aims, "to discover and develop the new and to develop empirically grounded theories" (Flick, 2009, p. 15).

Schwartz-Barcott and colleagues (2002) characterized three strategies for theory development: **theoretical selectivity** (the linking of selected concepts with existing theories), **theoretical integration** (the incorporation and testing of selected concepts within a particular theoretical perspective), and **theory creation** (the generation of

relational statements and the development of a new theory). Various types of qualitative methodologies can be classified within each theory development strategy depending on their aims, assumptions, and principles (Cleland, 2017), and include (Figure 2.1): qualitative content analysis (QCA), ethnography, phenomenology, and grounded theory (Chen & Teherani, 2016). While arguments can be made against classifying complex qualitative methodologies onto a simplistic scale, it does provide one way of comparing the epistemological positions of these inquiries (Barnett-Page & Thomas, 2009).

Figure 2.1: Different types of qualitative methodologies placed along a spectrum of theory development

Theoretical Selectivity (the linking of selected concepts with existing theories) — **Theoretical Integration** (the incorporation and testing of selected concepts within a particular theoretical perspective) — **Theory Creation** (the generation of relational statements and the development of a new theory)

QCA (summative) — **QCA (directed)** — **QCA (conventional)**

Straussian Grounded Theory — **Glaserian Grounded Theory** — **Charmaz's Constructivist Grounded Theory**

Thematic Synthesis

Ethnography

Phenomenology

Several methods have been cited in the literature to qualitatively investigate simulation in healthcare education (Dornan et al., 2007; Feather et al., 2016; McGaghie, Siddall, Mazmanian, & Myers, 2009). Although similar in their goal to investigate complex social elements, each qualitative methodology has distinct assumptions and procedures that guide the research process. Qualitative content analysis (QCA) was ultimately used in this dissertation research to analyze interview transcripts and the open-

response questionnaire item, with reasons for this and additional details regarding this methodology described next.

Qualitative Content Analysis (QCA)

Qualitative Content Analysis (QCA) is an iterative process that essentially condenses text into content categories in order to validate or extend a theoretical framework, theory, or provide predictions or relationships about variables of interest (Hsieh & Shannon, 2005; Weber, 1990). Mayring (2014) explained that this technique preserves the strengths of quantitative analysis yet allows for the organic development of qualitative interpretation. Krippendorf (2004) defines QCA as, "a research technique for making replicable and valid inferences from texts to the contexts of their use" (p. 18). Context and precision are important concepts during the analysis process; the context of the overall discourse must be considered and the coding procedure must be clearly defined and accurately followed.

The use of qualitative content analysis (QCA) in research was initially described in the 1950's (Berelson, 1952), and has since been further expanded upon by Krippendorff (2004) and Mayring (2000; 2014). Utilization of QCA grew exponentially since the 1990's (Hsieh & Shannon, 2005), most notably in the fields of journalism, sociology, psychology, and business (Elo & Kyngäs, 2008), and broader applications including nursing research (Graneheim & Lundman, 2004), film production (Bullerjahn & Güldenring, 1994), online community communication (Pfeil & Zaphiris 2009), and LGBT studies (Dispenza, Harper, & Harrigan, 2016).

Three approaches to QCA have been described (Hsieh & Shannon, 2005):

conventional, directed, and summative QCA. The **conventional approach to QCA** is used to describe a phenomenon in which existing theory or research is limited and the researcher approaches the project without using preconceived categories; **the directed approach to QCA** (also described by Mayring (2000) as 'deductive category application') is a more structured process used when research about the phenomenon exists, but may be incomplete or would benefit from further investigation. Finally, the **summative approach to QCA** is the most quantitative approach in which usage of particular words or phrases are counted within their context to explore frequency distributions.

However, QCA as a qualitative methodology has received criticism. When using QCA, the researcher typically begins data analysis with an informed, yet strongly biased, viewpoint potentially blinding them to developing phenomena within the context of the study (Hsieh & Shannon, 2005). Several measures have been suggested to avoid overreliance on theory when conducting QCA, including establishing an audit process, in which a neutral party reviews coding definitions to increase accuracy of the predetermined categories (Hsieh & Shannon, 2005). The quantitative aspect of QCA has been described as formulaic (Merriam, 2009); however, several different QCA procedures have evolved, including the directed approach in which researchers have flexibility to incorporate emergent codes (codes that are discovered during analysis and are subsequently added to the codebook), while remaining cognizant of the plethora of research currently available regarding the particular area of interest.

This dissertation research employed the directed approach to QCA, for the following reasons. This approach accommodates the fact that researchers are unlikely to

begin a study with little background knowledge, which is a hallmark in some qualitative

designs, such as in constructivist grounded theory methodology (Charmaz, 2014). The

directed approach to QCA provided a qualitative framework for the extensive literature

review and initial research for the pilot study (see Chapter 4) that was conducted prior to

this dissertation research commencing. Other forms of qualitative inquiry (Chen &

Teherani, 2016), such as grounded theory (in which the purpose is to develop a

theoretical model explaining how a process or action functions), phenomenology (in

which the purpose is to understand the nature of a phenomenon through those that have

experienced the event, circumstance, or incident), or the conventional approach to QCA

were inappropriate for this particular research since several models of learning theories

and phenomena associated with HFPS already exist, as previously described in this

chapter. Lastly, the summative approach to QCA, while also methodical, was too

restrictive for this research due to the exploratory nature of the research questions and the

overall goals of this dissertation. Given these limitations and concerns, the directed

approach to QCA provided a scaffold for analysis while still allowing for flexibility in the

analysis process.

A qualitative HFPS study conducted by McCoy and colleagues (2016) assessed

the construct of 'engagement' (a novel topic in HFPS literature, measured as flow,

interest, and relevance) among 108 first-year medical students during HFPS scenarios

through a grounded theory approach; they triangulated data from observation notes,

classroom photos, tutor feedback, Likert ratings from exit surveys, & open responses to

assert that HFPS fosters engagement in medical students.

Summary of High-fidelity Patient Simulation in Medical Education

Simulation-based training has a rich history dating back to ancient periods, and then coursed through technological evolutions to become the HFPS seen in modern healthcare curricula. This method of instruction and assessment places learners in an authentic, experiential scenario, suspends their disbelief, and allows them to practice psychomotor tasks, communication, and valuable teamwork skills in a psychologically safe environment. Although challenges exist while implementing HFPS (such as initial resource investment, ongoing training and maintenance, and the possibility of negative transfer of training), the benefits of this invention are well documented. It is difficult to assess the direct and indirect effects of HFPS on student achievement; however, research on the impact of HFPS is growing and thus adding to the existing pool of literature.

In this chapter, several gaps in the literature were noted, including lack of studies investigating the influence of HFPS on self-efficacy in medical education and no studies looked at resident perceptions regarding HFPS experienced during their medical education. This dissertation research will add a unique perspective of those medical students and medical residents who were exposed to HFPS in their medical curriculum with the aim to contribute filling these specific gaps in current research adding to the existing HFPS medical education literature.

This chapter provided the foundation for this dissertation research; the history of medical simulation was outlined, the concept of simulator fidelity and modern simulation technology was described. This chapter also presented advantages and challenges when utilizing HFPS, as well as specific learning theories associated with the use of HFPS in medical education. The chapter concluded with a look at current trends in HFPS research

and laid out the methodology that will guide the qualitative portion of this dissertation research. The next chapter will dive into the details regarding the methodology of this research and Chapter 4 presents the results from a pilot study conducted prior to the main dissertation research. The results from the investigation into the main research questions will then be discussed in Chapters 5, 6, and 7. Final conclusions, evidence-based recommendations, limitations, and future directions conclude this work in Chapter 8.

CHAPTER 3: RESEARCH QUESTIONS AND METHODOLOGY

This research was a mixed methods case study of a high-fidelity patient simulation (HFPS) center at Indiana University School of Medicine, Bloomington (IUSM-B), a regional campus of a large medical school located in the Midwestern United States. The overall goal of this research was to generate a comprehensive understanding of the role of high-fidelity simulated learning opportunities throughout the medical curriculum. Both medical students and recent medical graduates, who are currently working in residency programs, were included in this study to investigate three research questions. Data was derived from multiple sources, including questionnaire responses from medical students, scores from a standardized examination, and opinions from medical residents, to obtain a thorough understanding of HFPS at IUSM-B.

This chapter describes the research questions and methodology. The quantitative results and discussion are presented in Chapter 5 and the qualitative results and discussion are found in Chapter 6 and Chapter 7. This chapter presents the research questions first, followed by a description of the study population and sampling techniques. The study context, including the architecture and software utilized in the Indiana University Bloomington Inter-Professional Simulation Center (IUBIPSC) is discussed next. This chapter concludes with an explanation of the research strategies utilized and data collection instruments that were created to examine each research question.

Research Questions

Three questions formed the foundation for this investigation into the impact of high-fidelity patient simulation (HFPS) in medical education at Indiana University School of Medicine, Bloomington (IUSM-B). The IUSM-B campus served as the intervention group because medical students were exposed to HFPS. IUSM-B was compared to two other regional IUSM centers (IUSM-Evansville and IUSM-Fort Wayne), whose medical students were not exposed to HFPS, and thus served as the control group. Research Questions 1 and 2 will be examined using quantitative methodologies; thus, hypotheses and rationales accompany them. Research Question 3 is a qualitative inquiry and therefore does not have an *a priori* hypothesis.

Research Question 1

What is the relationship between ratings of clinical self-efficacy and clinical competence, as measured by scores on final performance-based assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?

Hypothesis

Statistically significant positive correlations will exist between clinical self-efficacy and clinical competence on final OSCEs among second-year (MS2) and third-year medical students (MS3) exposed to high-fidelity patient simulation (HFPS), compared to those second-year and third-year medical students not exposed to HFPS. Little impact will be observed among first-year medical

students (MS1) exposed to HFPS compared to those first-year medical students not exposed to HFPS.

Rationale

Bandura's (1986) social cognitive theory posits that students' beliefs in their capabilities to succeed on specific tasks, or **self-efficacy**, are predictors of their academic achievement, motivation, and behavior. HFPS is claimed to be an effective method to obtain clinical experience through deliberate practice (Anderson et al., 2008), which imparts high evaluations of self-efficacy and aids in attaining competencies (Fincher & Lewis, 1994; Issenberg et al., 1999). Therefore, use of simulation in medical education should impart learners with a sense of ability manifesting as clinical competence. For instance, in a study of 100 third-year medical students at the Medical College of Georgia (MCG), Fincher and Lewis (1994) found a significant positive correlation regarding the number of times common bedside procedures had been performed and self-perceived level of competence.

Morgan and colleagues (2016) investigated experiential education in 299 undergraduate medical students using HFPS and discovered a statistically significant improvement in performance on a pharmacology written test and improved team performance on checklist and global rating scores on all but one simulation scenario. Analysis of student perceptions noted positive comments regarding the realism of the environment and that the simulated session was a valuable learning experience. The researchers concluded that HFPS allows students to safely apply theoretical knowledge to practice. Furthermore, Mavis (2001) stated that in order to foster accurate self-appraisal

among students, an ideal healthcare curriculum should incorporate a variety of experiential learning situations coupled with meaningful, constructive feedback, which is achieved with HFPS.

The term 'competence' has extensive meaning within medical education. A report drafted by Indiana University School of Medicine (IUSM) explains that a competency-based curriculum emphasizes accountability through outcomes that learners should accomplish at the end of their training (The Indiana Initiative, 1996). Carraccio and colleagues (2008) explained that integration of basic and clinical sciences in the first two years of medical school effectively develops pattern-based recognition, a form of clinical reasoning seen in "competent" practitioners. Furthermore, levels of competence vary among grade levels. In a longitudinal study over 21 years, Benner (2004) observed changes in the development of expertise as nurses became more skilled over time.

For this research, a proxy variable for clinical competence was used. **Proxy variables** are measures used for an unobservable quantity of interest (Clinton, 2004). Although a proxy variable is not a direct estimate of the desired measurement, proxy variables are commonly used in social science research because it is often difficult, or impossible, to quantify a measure of interest. A proxy variable relates to the unobserved variable of interest in a way that allows researchers to approximate the extent of influence of the unobservable variable of interest. Therefore, competent behavior imparted from performance-based simulation was evaluated through a proxy variable of a performance-based assessment, known as the Objective Structured Clinical Examination (OSCE), which will be fully described later in this chapter and Chapter 5. Using the OSCE as a proxy measure for assessing clinical competence has been utilized in a variety of medical

and other healthcare-related professions research (Beckham, 2013; Brand & Schoonheim-Klein, 2009; Byrne & Smyth, 2008; Hsu, Chang, & Hsieh, 2015; Jolly et al., 1996; Mårtenseson & Löfmark, 2013; Mavis, 2001; Nolan, Desale, Padmore, Weissinger, & Furlong, 2017; Weiner et al., 2014).

It is hypothesized that no statistically significant effect will be observed on OSCE scores between first-year medical students exposed to HFPS (intervention group, IUSM-B) compared to a control group of first-year medical students from two other campuses (IUSM-Evansville and IUSM-Fort Wayne) who were not exposed to HFPS, because first-year medical students at IUSM-B are exposed to fewer simulations (specifically detailed later in this chapter) than the second-year and third-year cohorts, and thus are hypothesized to not show much difference from the control group. However, access to and participation in simulations increases in the second-year and third-year at IUSM-B (again, described in more detail later in this chapter). Therefore, it is hypothesized that there will be statistically significant positive correlations between clinical self-efficacy and OSCE performance scores among the intervention group compared to the control group.

Research Question 2

To what extent do simulation performance scores predict ratings of clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?

 2a. To what extent do simulation performance scores predict ratings of clinical self-efficacy among second-year medical students exposed to HFPS?

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2b. To what extent do simulation performance scores predict clinical

competence, as measured by scores on the final OSCE, among second-year

medical students exposed to HFPS?

Hypothesis

Higher simulation performance scores (granted from a supervising instructor) will

positively predict achievement of clinical competence, as measured by higher

scores on the final OSCE. Higher simulation performance scores will also

positively predict more accurate appraisal of clinical self-efficacy, as measured by

self-evaluations from the questionnaire.

Rationale

Early exposure and experience with immersive, high-fidelity simulated

environments primes novice learners to think like a physician and successfully perform

clinical skills. Experience with HFPS has been shown to enhance the attainment of

competencies (defined in the previous research question rationale) and learner self-

efficacy (Fry et al., 2015; Goldenberg et al., 2005; Kameg et al., 2010; Leigh, 2008; Lee

et al., 2016; Pike & O'Donnell, 2010; Roh, 2014; Stroben et al., 2016; Wright et al.,

2006). Self-efficacy was previously defined as the belief to successfully accomplish an

expected outcome (Bandura, 1977). Unfortunately, the terms 'self-efficacy' and

'confidence' are used synonymously in the literature. Although related, self-efficacy

refers to the personal judgment of one's ability to successfully perform a specific task

(Mavis, 2001). In contrast, while confidence also refers to personal belief, it does not specify the direction toward completing the task successfully (Bandura, 1997).

Second-year IUSM-B medical students are the focus of this particular research question because they are the only medical class to receive numerical scores for their HFPS performance. In support of the hypothesis that higher simulation performance scores will positively predict achievement of competence and a more accurate appraisal of clinical self-efficacy, an investigation determined the relationship between experiences during a primary care clerkship and confidence (Harrell et al., 1993). The authors identified four major variables (degree of patient management, prior exposure, progression through the curriculum, and performance or interpretation of laboratory work) that correlated with confidence among 60 third-year medical students. Three of those variables (degree of patient management, prior exposure, and performance or interpretation of laboratory work) were found to be main indicators that predicted 54% of the observed variance in confidence after a stepwise multiple-regression analysis. They concluded that active involvement, prior experience, and repeated practice in patient care management contribute to confidence; all of these factors are achieved while participating in simulated experiences during medical training. Since a primary benefit identified in HFPS literature is the opportunity to apply basic science content to an experiential application (Sheakley et al., 2016), it is hypothesized that HFPS will predict achievement of clinical competence, specifically defined for this research as performance on the OSCE.

Research Questions 1 and 2 address the quantitative facets of this dissertation research, which exclusively use numerical data and statistical methodologies. While the

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quantitative facets provide valuable information adding to the elucidation of the main research goal, much is left hidden regarding the personal experiences, attitudes, and beliefs of those experiencing HFPS. Research Question 3 elicits the qualitative facets, encompassing the perspectives of medical students and medical residents. As the following question is a qualitative inquiry, a previously established hypothesis was not included. Qualitative research is based on different epistemological and ontological assumptions than quantitative designs; therefore qualitative methods do not have independent and dependent variables or intend to test a hypothesis or a treatment effect (Tavakol & Sandars, 2014).

Research Question 3

How do first-year, second-year, and third-year medical students and medical residents perceive the utility of, and satisfaction with, high-fidelity patient simulation (HFPS) experienced during their education?

       3a. How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?

       3b. How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?

Although qualitative analysis of HFPS is ubiquitous in nursing education (Baxter et al., 2009; Botma, 2014; Feather et al., 2016; Ha, 2016; Landeen et al., 2015; Reising et al., 2011), there is little methodological qualitative research describing the personal

experiences of medical student and medical graduate perceptions of simulation adjuncts, including HFPS (Zafar, 2016). Qualitative responses from questionnaires and interviews with first-year, second-year, and third-year medical students of both the intervention and control groups will be analyzed using a directed approach to qualitative content analysis (QCA), a specific method of qualitative analysis that will be discussed in more detail later in this chapter. The qualitative results derived from the personal experiences of medical students will illuminate views regarding the efficacy of simulation in medical education and if they believe that this intervention had a demonstrable impact on their learning and clinical practice.

Additionally, the lack of longitudinal studies in the medical education literature researching the long-term effects of high-fidelity patient simulation (Sheakley et al., 2016) warrant an investigation into the viewpoints of medical graduates (i.e., residents) who experienced HFPS during their medical education. Discovering medical residents' perceptions of HFPS can be accomplished through **Q-methodology**, an exploratory systematic research technique that combines quantitative and qualitative procedures but does not attempt to hypothesize existing relationships. This methodology will be described in more detail later in this chapter. The results from the Q-methodology study intend to expand the understanding of differing viewpoints and shared perceptions of medical residents regarding the most beneficial aspects of HFPS experienced during their medical education along with the applicability of this educational intervention in their current medical careers. This data may aid in tailoring strategies to more fully meet the needs and expectations of future physicians (Chinnis, Paulson, & Davis, 2001).

The methodology underlying each research question will now be discussed in greater detail. First, the study population, recruitment methods, and subsequent sample used to investigate Research Questions 1, 2, and 3a are explained (Table 3.1). The overall simulation context of the research project is then described, including the architecture and software utilized in the Indiana University Bloomington Inter-Professional Simulation Center (IUBIPSC). This chapter then presents a description of the data collection instruments constructed and distributed to answer Research Questions 1, 2, and 3a that focus on medical students. The performance-based assessments used for the quantitative portions of this research will be explained next, followed by the interview methodology and the strategy used to analyze the interviews. This chapter concludes by describing the methodology underlying Research Question 3b, known as Q-methodology, used to investigate medical graduates' viewpoints about HFPS.

Table 3.1: Summary of the populations sampled and methods utilized to answer the
research questions

Research Question	Populations	Method	Data Collection Instruments	Chapter
1. What is the relationship between ratings of clinical self-efficacy and clinical competence, as measured by scores on final performance-based assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?	IUSM-B: MS1, MS2, MS3 IUSM-E: MS2 IUSM-FW: MS1, MS2, MS3	Independent samples *t*-tests; Pearson correlations; ANCOVA	Questionnaire (Appendix A and Appendix B) and final OSCE scores	5
2. To what extent do simulation performance scores predict ratings of clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?				
2a. To what extent do simulation performance scores predict ratings of clinical <u>self-efficacy</u> among second-year medical students exposed to HFPS?	IUSM-B: MS2	OLS regression	OLS regression using simulation performance (scores from supervising instructor) to predict self-efficacy (questionnaire, Appendix A)	5
2b. To what extent do simulation performance scores predict <u>clinical competence</u>, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?			OLS regression using simulation performance (scores from supervising instructor) to predict clinical competence (final OSCE score)	5
3. How do first-year, second-year, and third-year medical students and medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?				
3a. How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?	IUSM-B: MS1, MS2, MS3	Directed approach to QCA	Questionnaire (Appendix A) and interview transcripts	6

3b. How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?	IUSM-B: Classes of 2015, 2016, 2017	Q-methodology	Q-sort data (Appendix H) and follow-up interview transcripts	7

ANCOVA, analysis of covariance; HFPS, high-fidelity patient simulation; IUSM-B, Indiana University School of Medicine-Bloomington (intervention group); IUSM-E, Indiana University School of Medicine-Evansville (control group); IUSM-FW, Indiana University School of Medicine-Fort Wayne (control group); MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students; OLS, ordinary least squares; OSCE, Objective Structured Clinical Examination; QCA, Qualitative Content Analysis.

Methodology

The specific research questions related to medical students will be explored before the research question aimed at medical residents. The questions specific to medical students include Research Question 1 ("What is the relationship between clinical self-efficacy and clinical competence, as measured by scores on final performance-based assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?"), Research Question 2 ("To what extent do simulation performance scores predict clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?") and Research Question 3a ("How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?").

For these medical student research questions, first the population and sample obtained for this portion of the dissertation research will be explained. This explanation is followed by a detailed description of the simulation experience at IUSM-B, including how the scores are obtained for the second-year medical students for the "simulation

performance" variable of Research Question 2. A description of the data collection instruments used for Research Questions 1, 2a, and 3a, the "Medical Student Self-Efficacy and Simulation Perception Questionnaire – Intervention Group" (Appendix A) and the "Medical Student Self-Efficacy and Simulation Perception Questionnaire – Control Group" (Appendix B) will then be described as well as the theoretical foundations and validation of the questionnaire.

The performance-based assessment scores from the Objective Structured Clinical Examination (OSCE) used for the 'competency' variable in Research Questions 1 and 2b will be explained. Then, the interview methodology used to obtain data for Research Question 3a will be described as well as the qualitative analysis used to analyze the interview transcripts. This chapter concludes with a description of the Q-methodology procedure underlying Research Questions 3b ("How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?").

Medical Student Study Population and Sample

Nine campuses across the state of Indiana comprise Indiana University School of Medicine (IUSM). This study was carried out with three campuses within the IUSM system (Figure 3.1): the Bloomington campus (IUSM-B) has an immersive high-fidelity patient simulation (HFPS) center integrated into the curriculum and served as the intervention group; the control groups consisted of the Evansville campus (IUSM-E), which lacked a simulation center at the time of this research, and the Fort Wayne campus (IUSM-FW) which did not integrate a simulation center into the medical curriculum. These three campuses were chosen for this study because they had similar student

population sizes and similar curricula, including a combination of lecture, laboratory work, small-group collaboration opportunities, and clinical skills training. Other IUSM centers were not included in this study because they either had a much smaller or larger student population, and/or had curricula that varied from the pattern described above (these variations will be explained later in this section).

As this research was carried out at three specific campuses within IUSM, this dissertation research represents a case study design. **Case studies** are a type of qualitative research design that aim to develop an in-depth understanding through key themes of either one or a small number of specific cases (Chen & Teherani, 2016). Qualitative case study methodology has been cited as a valuable and rigorous approach in health science research to evaluate programs and develop interventions within specific contexts (Baxter & Jack, 2008).

Figure 3.1: Indiana University School of Medicine (IUSM) campus locations
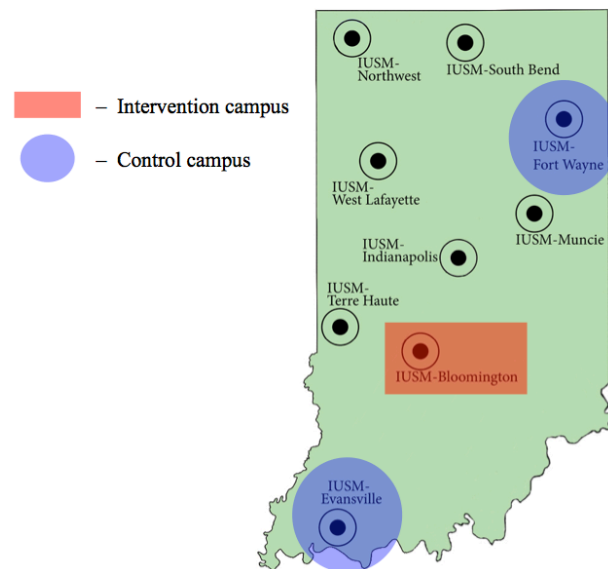
IUSM-Bloomington (IUSM-B) campus served as the intervention group; IUSM-Evansville (IUSM-E) campus and IUSM-Fort Wayne (IUSM-FW) campus collectively served as the control group. Image modified from https://inmedwiki.org.

Intervention Group Population and Sample

Three medical classes at IUSM-B collectively served as the intervention study population (Table 3.2): the class of 2018, the class of 2019, and the class of 2020. These classes were selected because they were current medical students at the time of this study and had experienced at least one year of HFPS within the IUBIPSC. Total class population sizes, that were subsequently sampled, included: First-year (MS1, class of 2020, $N=36$), second-year (MS2, class of 2019, $N=36$), and third-year (MS3, class of 2018, $N=8$) medical students. After recruitment, which is explained later in this section, the total number of participants from IUSM-B included in this portion of the study was: first-year (MS1, class of 2020, $n=17$), second-year (MS2, class of 2019, $n=12$), and third-year (MS3, class of 2018, $n=5$) medical students. Fourth-year medical students were excluded from this study because the final year is dedicated to professional development, individualized career exploration, and advanced clinical training; the varied curriculum and specialization for each fourth-year IUSM student was determined to confound the study.

Table 3.2: IUSM populations and samples used in this study

Medical Class	Class Year	Pop-ulation Size (*N*)	Number Completed Questionnaire (*n*) (% response rate)	Final OSCE Score	Simulation Score	Number Interviewed
Intervention Group (simulation center): IUSM-B						
MS1	2020	36	17 (47.2)	✓	N/A	7
MS2	2019	36	12 (33.3)	✓	✓	2
MS3	2018	8	5 (62.5)	✓	N/A	3
Control Group (no simulation center): IUSM-E						
MS1	2020	24	0 (0)	✓	N/A	0
MS2	2019	23	7 (30.4)	✓	N/A	3
Control Group (no simulation center): IUSM-FW						
MS1	2020	32	12 (37.5)	✓	N/A	2
MS2	2019	29	9 (31.0)	✓	N/A	3
MS3	2018	12	4 (33.3)	✓	N/A	1

IUSM-B, Indiana University School of Medicine-Bloomington; IUSM-E, Indiana University School of Medicine-Evansville; IUSM-FW, Indiana University School of Medicine-Fort Wayne; MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students; OSCE, Objective Structured Clinical Examination. A check mark indicates that data was collected and analyzed for that instrument.

Control Group Population and Sample

Two other IUSM campuses collectively served as the control group (Figure 3.1): IU Evansville (IUSM-E) and IU Fort Wayne (IUSM-FW). These campuses were chosen to comprise the control group because they either lacked a high-fidelity patient simulation center during data collection (IUSM-E) or did not frequently (i.e., once a year, with formative feedback only) utilize one in their program (IUSM-FW). However, as of 2018, a new facility is currently under construction at IUSM-E that will include a high-fidelity

simulation center. IUSM-FW did have a simulation center within the nursing department of Indiana University-Purdue University Fort Wayne (IPFW); however, the medical students did not regularly use the facility and first-year medical students did not access the center at all.

In addition to lacking a simulation center, IUSM-E and IUSM-FW were also selected for the control group because they had similar class sizes to IUSM-B. One IUSM campus was incompatible for the control group due to disproportionate class sizes; the Indianapolis campus (IUSM-IUPUI) was excluded from the control group due to the large class sizes of approximately 150 medical students per year, which is four times that of the intervention campus (IUSM-B). The medical curricula at IUSM-B, IUSM-E, and IUSM-FW were similar as well, which included lecture, laboratory work, small group activities, and clinical skills training at the time of this study. This curricular model was not the same for every campus within IUSM during the data collection period for this research. For instance, at the time of this writing, the curriculum at IUSM-Northwest in Gary, Indiana used an entirely problem-based learning (PBL) approach, and many courses at IUSM-South Bend (IUSM-SB) were taught as block courses and used team-based learning (TBL) extensively in selected courses. Finally, IUSM-E and IUSM-FW also had faculty who were willing to assist in distributing the study invitation emails, which was a requirement of this study to conform to the IRB protocol, and further detailed in the recruitment section.

In terms of total class sizes, IUSM-E included first-year (MS1, class of 2020, $N=24$) and second-year (MS2, class of 2019, $N=23$) medical students (Table 3.2). After recruitment (which is explained later in this chapter), the total number of participants

from IUSM-E included in this study sample was seven second-year medical students (MS2, class of 2019, $n=7$). The total number of students who attended IUSM-FW at the time of this study included: first-year (MS1, class of 2020, $N=32$), second-year (MS2, class of 2019, $N=29$), and third-year (MS3, class of 2018, $N=12$) medical students. After recruitment, the total number of participants included in this study sample was: first-year (MS1, class of 2020, $n=12$), second-year (MS2, class of 2019, $n=9$), and third-year (MS3, class of 2018, $n=4$) medical students (Table 3.2). The theoretical basis of the sampling strategies will now be discussed, which is followed by a description of the recruitment techniques employed for this study.

Theoretical Foundations of the Sampling Strategies

The portion of this research study utilizing medical students (Research Questions 1, 2, and 3a) used nonprobability criterion-based selection for both the intervention and control groups. **Nonprobability criterion-based selection**, also referred to as 'purposive sampling,' requires that participants meet predetermined attributes for inclusion in the study (LeCompte & Preissle, 1993). Defining specific criteria for selection ensures that the sample will provide information-rich cases for in-depth study that directly reflects the study's purpose (Merriam, 2009). The specific sampling strategy described under the larger domain of nonprobability criterion-based selection, known as 'maximum-variation (or quota) sampling,' was utilized (LeCompte & Preissle, 1993). **Maximum-variation sampling** (or 'quota sampling') provides a representative subset that approximates the larger population (Patton, 1990). This sampling technique is used to describe principal themes and common patterns of experiences that are central to a program enabling

description of the variation within the group, while simultaneously investigating shared outcomes (Patton, 1990).

Maximum variation sampling was employed for Research Questions 1, 2, and 3a and was accomplished by including medical students in multiple years of the medical curriculum (e.g., first-year, second-year, and third-year students from the classes of 2020, 2019, and 2018, respectively), who were either exposed to HFPS (the intervention group) or those who had no or limited access to a simulation center (the control group). Participants for the intervention group were current first-year, second-year, or third-year medical students during the 2016-2017 academic year, attended IUSM-B, and regularly participated in clinical simulations at the IUBIPSC. These specific criteria established a standardized experience among the intervention participants. Those in the control group did not participate in simulations at all or participated in a few simulations, but participation was inconsistent throughout their curriculum.

Intervention Group and Control Group Recruitment

All participants were recruited between March and May 2017 (Table 3.3), depending on the specific date of the final performance-based evaluations (OSCE) for each campus and medical school class year (these examinations will be defined and described later in this chapter). Medical students were recruited through a campus representative, knowledgeable of the students' emails, for distribution to each class per the Indiana University IRB approved protocol (information detailed in the next section), and included: the Medical Sciences Student Services Representative (IUSM-B); the Assistant Professor of Anatomy and Cell Biology (IUSM-E); and the Administrative

Support Coordinator (IUSM-FW). An email invitation to complete the study's

questionnaire (Appendix A and Appendix B) was sent to each campus representative for

them to forward to their medical classes. A study information sheet (Appendix C) was

also attached to the invitation email for distribution to all participants (intervention and

control groups). The representatives from each campus then forwarded the email for

distribution to their respective campus cohorts. A reminder email was sent to the

representatives for distribution to the students approximately one week later.

Table 3.3: Recruitment email distribution schedule and dates of OSCE administration

	Date of OSCE	Date of 1st email	Date of 2nd email
IUSM-Bloomington (intervention group)			
MS1	May 10-11, 2017	April 20, 2017	May 1, 2017
MS2	May 1-2, 2017	April 20, 2017	April 28, 2017
MS3	*	April 20, 2017	May 1, 2017
IUSM-Evansville (control group)			
MS1	May 10, 2017	April 20, 2017	May 1, 2017
MS2	April 6, 2017	March 27, 2017	April 3, 2017
IUSM-Fort Wayne (control group)			
MS1	May 17, 2017	May 1, 2017	May 10, 2017
MS2	April 21, 2017	April 11, 2017	April 17, 2017
MS3	*	April 11, 2017	April 17, 2017

* MS3's are contacted by Indianapolis to schedule a time to take the end-of-third-year
  OSCE. The OSCE date was thus hypothesized to be sometime in June by consulting
  with the Fairbanks Hall Simulation Center Calendar and searching for "EO3Y OSCE"
  on the following website (Accessed April 1, 2017):
  <http://iuhealthweb.ungerboeck.com/coe/coe_p1_all.aspx?sessionid=
  ej6fd5fg2fc8ff5fe2>.

Ethical Approval

All components of this research were reviewed by the Indiana University

Institutional Review Board (IRB) and granted exempt status (protocol #1610985662 for

the portion of this study concerning the medical students; protocol #1610007515 for the

Q-methodology study of medical residents; protocol #1709187553 for the interviews

conducted with faculty and staff associated with HFPS found in Chapter 8). All

participants received a study information sheet (Appendix C, Appendix F, and Appendix

L), which included details regarding the purpose of this study, their role and

responsibilities for inclusion in this study, a reminder that their participation was

voluntary, their ability to withdraw from the study at any time without penalty, and

incentive to participate if applicable (all medical students and medical residents were

informed of their entry into a random drawing for a $100 Amazon.com Gift Card upon

completion of the questionnaire or Q-methodology study; the faculty and staff were not

offered an incentive).

The next section describes the simulation context of the intervention group in

greater detail. This section begins with a discussion of the IUBIPSC architecture then

describes the first-year, second-year, and third-year medical student simulation

experiences.

The Simulation Experience at Indiana University School of Medicine, Bloomington (IUSM-B)

In 2012, Indiana University School of Medicine (IUSM-B) and the Indiana

University School of Nursing (IUSON) in Bloomington invested resources and a

substantial financial commitment to introduce simulation-based learning to their allied

healthcare programs. Construction of the simulation center began in August converting a

large classroom in an existing campus building into the Indiana University Bloomington

Inter-Professional Simulation Center (IUBIPSC), with the first simulations occurring in January 2013 (Appendix D).

Equipped with two debriefing rooms, one centralized control center, and two simulated clinical environments, the IUBIPSC regularly immerses students in authentic clinical scenarios at all levels of the medical and nursing programs. The two clinical simulated environments include an Intensive Care Unit (ICU) room and an Obstetrics and Gynecology (OB/GYN) Labor and Delivery room. Both rooms are complete with real hospital beds, touchscreen monitors, medical supplies, equipment, and wall-mounted oxygen, suction, and medical air. In addition to simulations, the IUBIPSC also provides students with medical training, such as Advanced Cardiac Life Support (ACLS) and skills workshops, such as use of ultrasound and bedside procedures. One full-time Simulation Coordinator conducts all of the simulations along with at least one clinical faculty member from the medical school (for medical student simulations) and from the nursing school (for IPE simulations). The Simulation Coordinator operates several high-fidelity manikins manufactured by Laerdal Medical Corporation (Stevangen, Norway) from the control room, including: SimMan® 3G, SimMom® full-body birthing simulator with SimNewB® infant simulator, Simjunior® a smaller replica of the adult simulator, and Harvey® Cardiopulmonary Patient Simulator (Figure 3.2).

Figure 3.2: High-fidelity patient manikins manufactured by Laerdal Medical Corporation
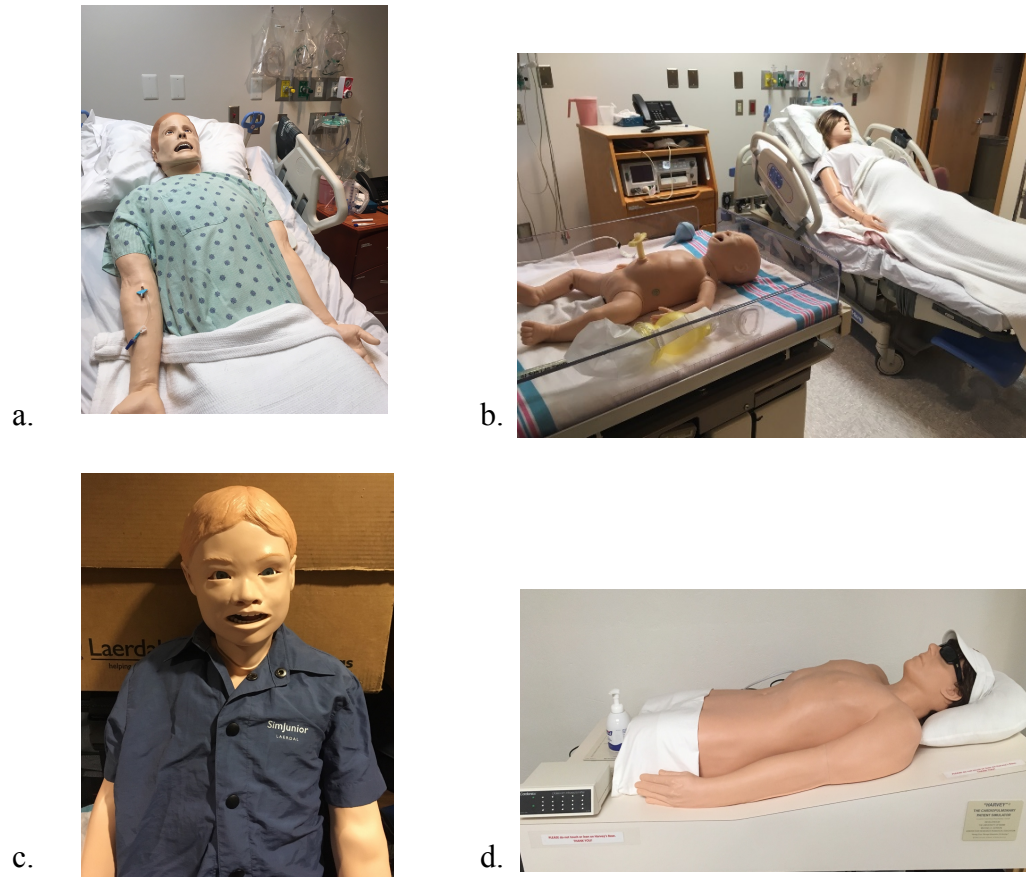
a., SimMan® 3G; b., SimMom® full-body birthing simulator with SimNewB® infant simulator (note that Laerdal Medical Corporation also manufactures a SimBaby 9-month-old pediatric manikin, which the IUBIPSC did not have at the time of this writing); c., Simjunior®; d., Harvey® Cardiopulmonary Patient Simulator.

Faculty-developed rubrics are used to organize the critique of simulation performance and are referred back to in the discussion during the debriefing session following the actual simulated event. The rubrics allow faculty to quickly assess the medical students' performance, initiates the debriefing dialogue, and highlights areas for faculty to address to the students for the future. IUSM-B faculty developed all of the simulation rubrics, and thus affected what they value in assessment of simulation

performance, which may have not necessarily been based on the literature (D. Carr, personal communication, June 16, 2017). At the time of this writing, the rubrics had not been assessed for reliability or validity and faculty admitted to leniency while assessing students during simulations (D. Carr, personal communication, June 16, 2017).

All simulations for first-year and third-year medical students are non-graded and used for formative feedback only (the reason for this is described later in this section). Those simulations for second-year medical students were graded and incorporated into their Foundation of Clinical Practice (FCP) course grade. The aggregate scores from these second-year medical simulations were used to answer Research Question 2.

Prior to all simulations, students are provided an email containing preparatory guidance as to what general conditions or systems they may encounter during the simulation, they receive advice on where to conduct independent study prior to the simulation (encouraging a lifelong learning mentality), and the specific rubric that the faculty will use during their assessment. This preparatory advice becomes limited as students progress through the curriculum and obtain more sophisticated perceptions of the course content and simulation routine.

The typical simulation sequence at IUSM-B (Figure 3.3) either has one or two medical students going through the simulation, or during interprofessional education (or IPE) simulations, one medical student and one or two nursing students will go through the simulation together. Simulations begin with an orientation by the Simulation Coordinator known as the **pre-brief** which usually lasts about five minutes and consists of the Simulation Coordinator orienting the students to the room, the patient manikin, touch screen bedside patient monitor, and the location of any medical supplies and

equipment required to successfully complete the simulation. The simulation then occurs, ranging from 10-15 minutes or until an appropriate diagnosis and treatment plan is reached, whichever occurs first. The students then exit the simulation room and enter an adjacent room for the **debrief** with a faculty member for about 10-15 minutes. The debrief session is a semi-structured discussion using evidence-based facilitated discourse techniques that usually begins by asking learners what they believe went well during the simulation, providing guidance on areas to work on for the future, and affords students the opportunity to discuss their performance with the supervising faculty members.

After the debrief, the students are prompted to scan a Quick Response (QR) code with their smartphones to take an anonymous six question survey intended for the Simulation Coordinator's knowledge about how they perceived the simulation.

Figure 3.3: Typical simulation sequence at IUSM-B
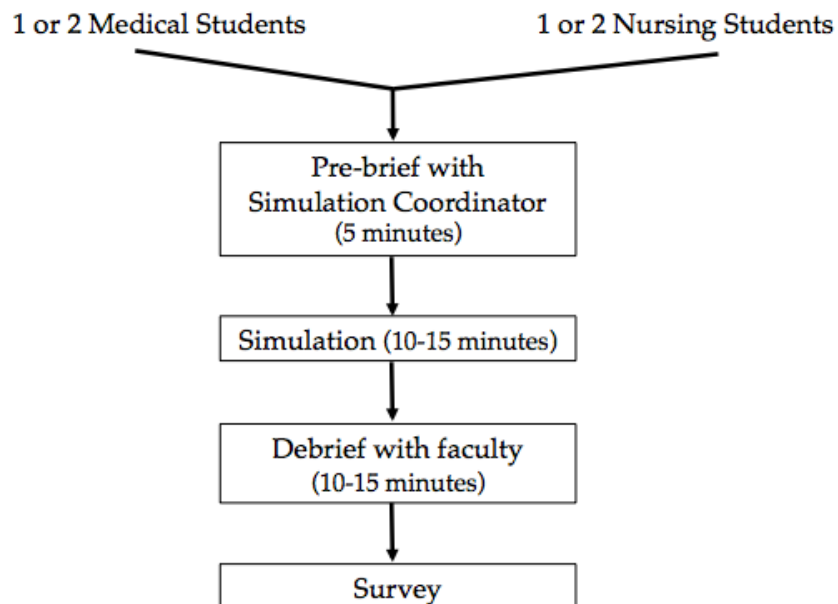
First-year Medical Student (MS1) Simulations at IUSM-B

First-year medical students at IUSM-B are exposed to the IUBIPSC within the first few days of medical school. These students participate in one simulation in their first semester and another simulation during their second semester of their first school year.

The first simulation is a **Basic Life Support (BLS) Simulation** that occurs in the fall, and in the spring first-year medical students participate in an **Interprofessional Education (IPE) Asthma Simulation**. The BLS simulation requires students to revive a patient manikin experiencing cardiac arrest. They must accurately conduct chest compressions and demonstrate appropriate emergency code initiation.

Interprofessional education (IPE) simulations, including the IPE Asthma Simulation in the spring, involve teams of one or two second-year nursing students paired with one first-year medical student. The Simulation Coordinator will orient the group of students together before the simulation begins during the **pre-brief**, (previously described). The simulation then begins with the nursing student(s) entering the patient's room, obtaining the patient's medical history, vital signs, and discovering the primary cause of the patient's complaint. After a few minutes have elapsed, the medical student then enters the room and a hand-off of patient information occurs between the nursing students and the medical student, known as **SBAR** (a first-letter mnemonic standing for situation, background, assessment, and recommendation). Occasionally, another student or faculty member will play the role of the patient's family member and interact with the students during the simulation. The healthcare team then works cooperatively to diagnose and manage the simulated patient's condition.

Faculty members observe the simulation room from the debrief room using a one-way mirror and/or closed-circuit television (CCTV), and evaluates the students' performance using the faculty-developed standardized checklist (described previously), making notes to discuss during the 10-15 minute debrief session immediately following the simulation. The simulation concludes either when a diagnosis and treatment plan is formulated or a given amount of time has elapsed. The students then move into an adjacent room to begin the **debrief** with medical and nursing faculty members to discuss their performance and thought processes during the simulation (previously described).

Second-year Medical Student (MS2) Simulations at IUSM-B

The number of simulations increase within the second year of medical school at IUSM-B. Second-year medical students at IUSM-B participate in approximately one summation simulation in the IUBIPSC per block of course material, or approximately two summation scenarios every semester. **Summation simulations** are simulated experiences occurring at the end of each block of lecture material that allow students to practically apply theoretical classroom knowledge to an experiential activity in the simulation center. All summation simulations are designed to integrate coursework with clinical skills and have explicit objectives that are provided to students prior to the simulation.

Two summation simulations occur during the fall semester, and each simulation is worth 16 points. First, medical students experience a **Sim-Man Cardiology Summation Simulation**. Faculty created six different cardiology scenarios, which are randomly assigned to students; for example, one scenario is infective endocarditis. Later during the

fall semester, students experience a **Sim-Man Pulmonary Summation Simulation**.

Again, six different pulmonary scenarios are randomly assigned to students, such as

chronic obstructive pulmonary disease (COPD). The fall semester concludes with the

Sim-Man Megacode IPE Simulation where teams of medical students and nursing

students collaborate together to revive a simulated patient experiencing cardiac arrest.

This IPE simulation is worth 70 points.

The first spring semester summation simulation is the **Sim-Man Block 1 Endo**

Summation Simulation in which six different scenarios concentrate on endocrine

pathology, such as Addison disease, and is worth 16 points. The second 16-point

summation simulation that occurs later in the spring semester is **Sim-Man Block 2**

Neuro Simulation where three scenarios cover various neurologic conditions, such as

cerebral stroke. The final IPE simulation at the end of the spring semester is a **Detective**

Sim-Man Case. This simulation presents one of six scenarios randomly to IPE teams,

where students may encounter a patient with pneumonia, ulcer, cholecystitis,

diverticulitis, myocarditis, or pancreatitis. This final IPE simulation is worth 70 points.

The combination of all scores from the summation simulations and the IPE simulations

are worth 3.5% of the total ICM2 course grade.

Medical students participate in summation simulations individually, which begins

with a five-minute pre-brief with the Simulation Coordinator (previously described). The

simulation is followed by a 10-15 minute simulated scenario, in which students practice

their patient routine and are encouraged to verbally articulate their thought processes. The

simulation ends when the diagnosis and treatment is reached, or if an established amount

of time has elapsed. A faculty member observes the simulation room from the debrief

room using a one-way mirror and/or closed-circuit television (CCTV), and evaluates the student's performance using a standardized faculty-developed checklist, making notes to discuss during the 10-15 minute debrief session immediately following the simulation.

In addition to summation simulations, second-year medical students participate in interprofessional education (IPE) simulations with one or two nursing students as a team once a semester. These simulations are similar in format to summation simulations (including a pre-brief, simulation scenario, and debrief); however, these IPE simulations have the same format as the first-year IPE simulation, in which one or two nursing students enter the simulation initially and an SBAR of information occurs when the medical student enters the simulation.

As was previously noted, only the second-year medical student simulations are graded (16 points for each summation simulation and 70 points for the IPE simulations). Specific faculty-developed rubrics accompany each simulation case. The faculty member then uses the rubric as well as notes made while observing the student for the discussion during the debrief following the simulation. The simulation scores from all of these summation simulations and IPE simulations from the 2016-2017 academic school year of the second-year medical student participants in this study were aggregated and used as the 'simulation score' variable in Research Question 2.

Third-year Medical Student (MS3) Simulations at IUSM-B

Like first-year medical students, third-year medical students also participate in simulations with formative assessment only, rather than a graded component as seen with second-year medical students. The third-year simulations are not graded because they are

not part of the formal clerkship curriculum; these simulations are offered to students as a learning opportunity rather than a didactic session (S. Tieman, personal communication, April 30, 2018). These students are exposed to two HFPS in the fall (an **Advanced Cardiac Life Support (ACLS) Simulation** and a **Diabetic Ketoacidosis (DKA) Simulation**), then a **Progressive Simulation** in January of their third year and a **Trauma Simulation** in late spring of the same semester. Like the other medical years, third-year medical students are sent an email by the physician-faculty member responsible for the simulation. The Progressive Simulation aims to realistically imitate actual clinical practice by asking teams of two medical students to follow the course of a patient's diagnosis and subsequent treatment in four stages beginning from the emergency room (ER), then following the patient's case through the intensive care unit (ICU), then onto the floor, then finally seeing the patient for a last follow-up appointment in a doctor's office. As the environment shifts the story changes to reflect the progression of the patient's condition. In reality, each stage takes approximately 15 minutes for students to complete, thus the entire Progressive Simulation is completed in a single afternoon, although it simulates approximately four patient days. Moving through these different progressions affords students the opportunity to understand the history of disease over a longer realistic period of time.

The Trauma Simulation is an opportunity for third-year medical students to review their knowledge of Advanced Cardiac Life Support (ACLS) in emergency situations. The students are told to review initial trauma management for adults, management of traumatic brain injuries, and pelvic trauma. The Progressive Simulation and Trauma Simulation are intended for formative feedback only, thus these simulations

do not have an accompanying numerical score and are considered pass/fail. In the event

of a failing assessment, the medical student will repeat the simulation without penalty.

Given these simulation experiences, a questionnaire was developed to investigate

medical student self-efficacy and perceptions of simulation and how clinical skills are

taught within their medical curriculum. The questionnaire was given to medical students

at the intervention and control campuses. The next sections will first describe the

structure of the questionnaire and then the theoretical foundations that guided the

construction of the questionnaire.

Description of the Questionnaire

The "Medical Student Self-Efficacy and Simulation Perception Questionnaire"

(Appendix A and Appendix B), referred throughout as simply "the questionnaire,"

consisted of three sections: the first section was an evaluation of self-efficacy and

contained thirteen questions; section two contained two questions (control group) or four

questions (intervention group) eliciting perceptions regarding clinical skills pedagogies,

preparation for future performance-based assessments (OSCE), and simulation perception

(intervention group only); and the third section asked participants four questions of

general demographic data.

The first section of the questionnaire, titled "Appraisal Inventory", was identical

for both the intervention and control groups. This section evaluated self-efficacy by

asking participants to rate their perceived ability to successfully execute basic clinical

skills. The clinical skills were organized into four self-assessment areas and one overall

assessment item. The four self-assessment areas included: 'Patient interview and medical

history,' 'Physical and diagnostic examinations,' 'Application of knowledge,' and 'Interpersonal skills and communication.'

Each of the four self-assessment areas included two to four sub-items consisting of progressive levels of clinical task demands. Specifically, the 'Patient interview and medical history' self-assessment area contained two self-assessment items: 'Interview a patient about their chief complaint in a hospital or clinical setting' and 'Accurately document a patient's medical history.' The next self-assessment area (Physical and diagnostic examinations) contained four items: 'Perform a physical examination in a hospital or clinical setting,' 'Interpret findings from a physical examination,' 'Order appropriate diagnostic tests,' and 'Interpret results from diagnostic tests.' The third self-assessment area elicited the integration factor of simulation (Application of knowledge) and included three self-assessment items: 'Integrate relevant basic science knowledge to the patient's presentation,' 'Create a list of appropriate differential diagnoses,' and 'Generate a treatment plan.' The fourth and final self-assessment area was 'Interpersonal skills and communication' and included three self-assessment items: 'Clearly communicate with other members of the healthcare team about a patient case,' 'Explain the reasoning of what is likely causing the primary complaint to a patient,' and 'Connect with patients and verify patient understanding.'

The response scale descriptors for all of these items were phrased in terms of "can do" statements (e.g., "Cannot do," "Moderately certain can do," and "Highly certain can do") on a unipolar, 100-point format with 10-unit intervals. Students rated themselves on the self-assessment items based on the scale provided. The scores from all four sections were aggregated for each study participant to create their composite rating of self-

efficacy score that was utilized in Research Questions 1 and 2a. The first section of the questionnaire concluded with a single overall self-assessment item. This question asked participants to indicate their perceived level of overall ability as a physician at this time in their medical career. The scale that was provided for this question was a scale of skill acquisition with increasing levels of competence, known as the **Dreyfus Model of Skill Acquisition** (Dreyfus & Dreyfus, 1980). (This model of skill acquisition is explained in the next section of this chapter, which discusses the theoretical foundations of the questionnaire.) The levels within the Dreyfus Model of Skill Acquisition included the following choices that students could select from on the questionnaire: Novice, Advanced beginner, Competent, Proficient, Expert, and Master. Descriptors for each level were also provided (see Figure 3.4 in the next section of this chapter), which were adapted from Park (2015).

The second section of the questionnaire, which contained perceptual data about the utility of educational activities utilized during the students' medical education and assessment of their performance, was slightly different between the intervention group (which consisted of four questions) and control groups (containing only two questions). Both control and intervention groups had one ranking question and one question related to the upcoming performance-based OSCE assessment. The intervention group (IUSM-B) second section of the questionnaire also contained the same ranking question as the control, and the same question related to the upcoming performance-based assessment as the control, but also contained two questions related to HFPS.

The ranking question for both groups asked participants to rank order five educational strategies used in medical school based on their preference for learning

clinical skills, with descriptors for three of the strategies seen in parentheses, and included: computer-based modules; Standardized Patients (real actors trained to play a patient); real patients; part-task trainers (for example, small groups learning around a part-task trainer such as Harvey® Cardiopulmonary Patient Simulator); and high-fidelity simulations (realistic room and responsive manikin). This question asked respondents to drag-and-drop their preferred teaching strategies for learning clinical skills from one, being the most helpful for learning clinical skills, to five, as the least helpful for learning clinical skills. The question related to the performance-based assessments for both groups asked participants how prepared do they feel to successfully complete their upcoming performance-based assessment (OSCE). This question had a bipolar scale with six options, which included: completely unprepared, moderately unprepared, slightly unprepared, slightly prepared, moderately prepared, and very well prepared.

In addition to the ranking question and preparedness for the OSCE question, the intervention group had two additional questions within the second section of the questionnaire related to their HFPS experience within the IUBIPSC. These additional questions inquired about perceptions of their experience with simulation and were used for further exploration during interviews conducted for Research Question 3a (discussed in Chapter 6). The first simulation question asked respondents what they had found most beneficial about participating in the simulations. Six options were given in addition to a seventh "other" fill-in option. The six options were derived from the literature (Chapter 2) and interviews from the pilot study (Chapter 4) and included: ability for repeated practice, exposure to a wide variety of patient cases, debriefing with a faculty member after the simulation, opportunities to integrate basic science knowledge with clinical

practice, working with nursing students during interprofessional (IPE) simulations, and I did not find simulation beneficial. The second simulation question was an open-response item asking participants to explain their overall impressions about their experience participating in simulations at the IUBIPSC.

The third section of the questionnaire was the same for both the control and intervention questionnaires and consisted of general demographic data, including: academic rank (current year in medical school), age, ethnicity (race), and gender. These variables were included because age at matriculation, race, and self-identified gender have all been shown to influence over-estimation and under-estimation of ability and academic performance in medical school (Blanch-Hartigan, 2011; Hall et al., 2016; Minter et al., 2005; Sheakley et al., 2016). For instance, a review of three meta-analyses of medical students' self-assessment by Blanch-Hartigan (2011) discovered that self-assessed performance improved with more years in medical school and female students underestimated their performance more than male students.

It is also recommended to include demographic data as the final section of a survey because this information is usually off-topic from the rest of the survey items and may be considered intrusive to some respondents (Hopper, 2012). The final item of the questionnaire was a dichotomous question that asked participants if they would consent to participate in a brief follow-up interview regarding their testing experience and overall reflections of the effectiveness of their clinical training. All participants were prompted at the end of the questionnaire to submit their email address for inclusion in a random drawing for a $100 Amazon.com Gift Card.

Theoretical Foundations of the Questionnaire

Now that the questionnaire has been described in the previous section, the theory underlying the construction of the questionnaire will now be discussed. The first section of the questionnaire used for this research to elicit self-efficacy was modeled after the self-assessment questionnaire administered to 137 third-year medical students at the Ann Arbor campus of the University of Michigan Medical School by Woolliscroft and colleagues (1993). Their self-assessment questionnaire consisted of 15 questions grouped into 10 divisions. Each division contained one to three individual items. Medical students assessed themselves on their performance on a five-point scale (from 1, rarely, to 5, almost always). For example, one of their self-assessment divisions was labeled "Medical history/interview" with a single item "I elicit an appropriate medical history." Another division was entitled "Interpersonal interactions" and contained two specific items: "I interact with patients and their families in a professional manner," and "I interact with other members of the health care team in a professional manner." The researchers grouped the items within each division, and then used the scores within each division for data analysis.

For this dissertation research, the "Medical Student Self-Efficacy and Simulation Perception Questionnaire" consisted of 12 specific items that were grouped into four self-assessment areas. The four self-assessment areas for this research are based on competencies expected of medical students outlined in a report authored by Indiana University School of Medicine (The Indiana Initiative, 1996), and included: 'Patient interview and medical history,' 'Physical and diagnostic examinations,' 'Application of knowledge,' and 'Interpersonal skills and communication.'

Given the confidentiality of the OSCE administered by Indiana University School of Medicine (IUSM), and the exam's annual augmentation after analysis of student performance, the specific items within each self-efficacy assessment area had to be hypothesized and subsequently validated by medical faculty knowledgeable about the OSCEs (for this research, two IUSM-B faculty were contacted, described in more detail below). A modified Delphi technique (or 'Delphi method') was employed to construct the items to measure self-efficacy of medical students. The **Delphi technique** is a structured procedure for group communication that reliably forecasts a likely outcome from consensus of judgment among experts when no historical data exists or novel influencing factors skew past data (Rowe, Wright, & Bolger, 1991; Stewart et al., 2000). The fundamental aim of this systematic process relies on the idea that the sum of group information is at least as great, but usually greater, than that of the individual (Hill, 1982). Originally developed in the 1950's, this process of survey consensus has been successfully used in a variety of academic settings, including anatomy education by faculty to develop an integrated simulation-based human anatomy medical course (Coombs et al., 2017).

According to Rowe et al. (1991), the classic Delphi technique encompasses four main characteristics: 1. Anonymity (in which questionnaires remain private to impart the most intellectual freedom and avoid social pressures); 2. Iteration (where several rounds refine the consensus over time); 3. Controlled feedback (occurs between rounds when the investigator analyzes and presents collected opinions); and 4. Statistical group response (obtained at the end of the procedure when group judgment is finally expressed as a median and standard deviation indicating the strength of consensus).

Tasks and skills to be included as the questionnaire items were hypothesized and derived from both the literature review (Chapter 2) and personal communications with the Indiana University Medical Student Education Assessment and Evaluation Specialist (A. Masseria, personal communication, August 15, 2016). After compiling these hypothesized tasks and skills into a list, two physician-faculty members from IUSM-B, who were knowledgeable of the OSCEs and who helped prepare their medical students for this exam, were asked to review the list. The two physician-faculty members submitted their initial opinions of the represented items, then the researcher consolidated their responses, and revised items for a subsequent round in which the physician-faculty members were made aware of the first round's summary. After self-reflection and submission of the physician-faculty members' judgment from the second round, the strength of consensus between the physician-faculty members as to which items should be included was calculated by averaging their agreement for inclusion of each item (based on the yes/no markings provided from each physician-faculty member).

Survey item phrasing and the response scale format for the first section of the questionnaire were constructed from recommendations by Bandura (2006): items should be tailored to specific activities and assess different levels of task demands; the response scale should be unipolar on a 10-point scale (with 1-unit intervals) or 100-point scale (with 10-unit intervals); the descriptors for the response scale should be phrased in terms of "can do" statements, since self-efficacy measures perceived capability (e.g., "Cannot do," "Moderately certain can do," "Highly certain can do"); finally the entire survey should use a nondescript title such as "Appraisal Inventory" rather than "Self-efficacy" to minimize response bias. The scale format, consisting of ten steps using a sliding bar, is

more sensitive, reliable, and more strongly predicts performance than an instrument using a 5-point Likert-type format (Bandura, 2006). This psychometrically stronger format enables respondents to make finer, more accurate discriminating judgments resulting in empirical quality of the results, and has been shown to more strongly predict achievement and behavioral indices (Pajares, Hartley, & Valiante, 2001).

Following the survey administered by Woolliscroft et al. (1993), the questionnaire also included one overall self-assessment item. For this research, the overall self-assessment item was based on the **Dreyfus Model of Skill Acquisition** (Dreyfus & Dreyfus, 1980). This model was developed by two brothers from the University of California, Berkeley and is used to quantify self-efficacy. Although no single model of competency attainment is comprehensive, the Dreyfus Model of Skill Acquisition illustrates the gradual developmental progression of attaining competence from novice through master (Dreyfus & Dreyfus, 1980). This model is an adequate rubric to guide classification as it reflects meaningful measures of ability and progression, and has been applied in the domain of healthcare education research (Benner, 2004; Green et al., 2009; Peña, 2010).

The model is a linear scale with bipolar anchors (e.g., from a novice employing rule-based practice to an intuitive master) that was initially used to describe skill development of fighter pilots, drivers, and chess players (Carraccio et al., 2008), but has since been applied to other domains such as nursing (Benner, 2004) and medical education (Green et al., 2009). The original model described five stages that learners progress through while attaining skills: novice, competence, proficiency, expertise, and mastery. This model has since been modified and expanded upon to include a sixth level

of advanced beginner, yielding the revised model: novice, advanced beginner, competent, proficient, expert, and master (Eraut, 1994; Park, 2015; Stewart et al., 2000). The updated model was used for the questionnaire (Figure 3.4). Descriptors were included for each level and adapted from Park (2015). The descriptors intended to help orient participants to the intended skills represented by each level.

Figure 3.4: Updated version of the Dreyfus Model of Skill Acquisition with bulleted descriptors, adapted from Park (2015)

Novice	Advanced beginner	Competent	Proficient	Expert	Master
• must follow specific rules • difficult to filter or prioritize information • requires maximum guidance	• less dependent on a mentor but still requires guidance and rules • able to filter and sort information	• comfortable with tasks from past experience • less dependent on rules • can adjust actions according to current situation • still relies on structured procedures for novel situations	• less rule-driven • more comfortable and flexible with novel situations • recognizes patterns	• responds to situations quickly and intuitively • can anticipate future situations and the unexpected	• expert who no longer needs principles • effortlessly recognizes subtle features • self-regulated and reflective

Questionnaire Validity, Reliability, and Distribution

A small pilot test of several experts in HFPS, including one Simulation Coordinator, two physician-faculty members (the same two who previously participated in the Delphi consensus) who utilized the IUBIPSC in their instruction, and three medical students who experienced at least one year of HFPS, reviewed the final version of the questionnaire for face and content validity. **Face validity** ensures that the questionnaire measures what it intends to measure through ease of use, clarity, and readability and is usually assessed by experts and a pilot study of participants (Burton & Mazerolle, 2011). **Content validity** of the questionnaire ensures that the questionnaire content accurately assesses all relevant aspects of the given topic (Burns et al., 2008). Modification of

question phrasing and approximate time to complete the questionnaire (approximately five minutes) were assessed from this questionnaire pilot test of HFPS experts and medical students. **Reliability**, or the degree to which the items of a tool or procedure are internally consistent (Artino, Durning, & Creel, 2010), was assessed by calculating a Cronbach's alpha, and is presented in Chapter 5.

As previously explained, campus representatives distributed the invitation emails to medical students, which contained a hyperlink to access the questionnaire. A study information sheet (Appendix C) was attached to the invitation email, explained the study's purpose and participant roles for inclusion in the study. The electronic questionnaire was administered on a secured network using Qualtrics software (Qualtrics, LLC, Provo UT, March-August, 2017). All participants were required to login before proceeding to the questionnaire using their Indiana University Central Authentication Service (CAS) credentials to verify identification and provide their electronic signature for the Family Educational Rights and Privacy Act (FERPA) release of information. Participants were informed that submission of the questionnaire signified acceptance of the data pairing procedure required for this research.

This protocol was reviewed and granted exempt status by the Indiana University Institutional Review Board (IRB), as previously stated (protocol #1610985662). The questionnaire concluded by thanking the respondent for their time and for helping to improve medical education, as recommended by Dillman, Smyth, and Christian (2014). The questionnaire was distributed prior to students taking their performance-based assessments (OSCE), as previously outlined in Table 3.3. The scores from these exams

served as the 'clinical competence' variable for Research Questions 1 and 2b. These exams will now be discussed in more detail.

The Objective Structured Clinical Examination (OSCE)

Medical students must participate in, and successfully pass, a plethora of examinations as they progress through their training. These examinations include the United States Medical Licensing Examination (USMLE), the National Board of Medical Examiners (NBME) examination, and (for most medical schools) the Objective Structured Clinical Examination (OSCE). Unlike the OSCE, the USMLE and NBME examinations are not performance-based assessments; therefore, they were not utilized to assess HFPS performance in this research. In support of this concept, Wayne et al. (2006) found no significant correlations between simulator training and USMLE Step scores among 41 postgraduate year 2 internal medical residents. However, a limitation associated with using required high-stakes examinations (such as the OSCE) as a proxy measure, is the introduction of measurement issues.

Recall from earlier in this chapter that 'clinical competence' is defined in this research as performance on the Objective Structured Clinical Examination (OSCE), a performance-based assessment of successful behavior. This proxy variable was based on a report authored by Indiana University School of Medicine (The Indiana Initiative, 1996), and defines a competency-based curriculum as one that emphasizes accountability through outcomes that learners should accomplish at the end of their training. From earlier in this chapter, proxy variables were defined as measures used for an unobservable quantity of interest (Clinton, 2004). Although the scope of this definition of clinical

competence in medical education is limited, the OSCE has been used as a proxy measure of competent behavior in previous investigations (Beckham, 2013; Brand & Schoonheim-Klein, 2009; Byrne & Smyth, 2008; Hsu et al., 2015; Jolly et al., 1996; Mårtenseson & Löfmark, 2013; Mavis, 2001; Nolan et al., 2017; Weiner et al., 2014). OSCEs typically use low-fidelity simulators or SPs (Maran & Glavin, 2003), and assess cognitive and psychomotor skills in addition to affective aspects such as communication and patient empathy. Since simulation also assesses competencies on various psychomotor and communication skills, the composite OSCE scores were utilized as a proxy for the clinical competence variable of this research.

Simulation has increasingly been used to assess competencies within several domains of healthcare (Scalese et al., 2007), and medical students are typically required to pass performance-based assessments throughout their academic career. According to the Association of Medical Education in Europe (AMEE) report, the OSCE is a tool to evaluate performance metrics in order to assess minimum acceptable professional performance standards of cognitive, psychomotor, and affective skills in simulated environments among medical students before proceeding through the medical curriculum in the United States, United Kingdom, and Canada (Khan, Gaunt, Ramachandran, & Pushkar, 2013). At the time of this writing, 133 United States medical schools, out of the 142 total US medical schools, require their students to pass a final OSCE examination ("AAMC SP/OSCE Final Examinations at US Medical Schools," 2018).

Although the OSCE is not required in all United States medical schools, Indiana University School of Medicine (IUSM) does require this assessment for several reasons: it is considered best practice in medical education to ensure that examinees can

demonstrate integration of prerequisite knowledge, skills, and affective domains in realistic settings; it compliments written-based assessments; it allows students to demonstrate competence that cannot be assessed otherwise, and the Liaison Committee on Medical Education (LCME) enquires about OSCEs in their accreditation review (B. Herriott, personal communication, January 22, 2018). The OSCE also provides preparation for the Step 2 Clinical Skills (CS) portion of the United States Medical Licensing Examination (USMLE), which is a nationally required assessment. The Step 2 CS exam evaluates the ability of medical students to conduct a medical history, perform physical examinations, and communicate their findings with a Standardized Patient (SP). However, OSCEs have been cited as being more clinically rigorous and provides better feedback on clinical skills proficiency to students than the pass/fail structure of the Step 2 CS exam (Alvin, 2016).

There is no universal OSCE or standard procedure for conducting OSCEs in medical education (Gormley, 2011). At IUSM, the final summative OSCEs are developed by clinical faculty, clerkship directors, and competency directors, among others. This team follows best educational practices from guidelines set forth in the literature regarding performance-based assessments in general, and OSCEs specifically. Additionally, the team refers to several articles published by the Association of Medical Education in Europe (AMEE) on OSCE history and structure (B. Herriott, personal communication, January 22, 2018).

Performance-based examinations, such as the OSCE, have proven both reliable and valid. As implied in the name, this exam intends to be "objective," thus providing a standardized experience for all students. Jolly et al. (1996) commented that, "an OSCE is

regarded as a more valid form of examination than many others for testing clinical competence" (p. 911). The OSCE is a summative, high-stakes performance-based assessment that presents healthcare students with diverse and varied scenarios to assess their knowledge and preparedness, ensuring each student achieves the minimum clinical standards required for the next phase of their education (Mavis, 2001). Originally developed in 1975 by Harden and colleagues, this exam has been validated as an effective and standardized measure to evaluate students' performance of isolated clinical skills and communication. Areas assessed on the OSCE usually include: patient examination, history taking, bedside practical procedures, and clinical data interpretation (Jolly et al., 1996; Liaw et al., 2012). The specific OSCE encountered by medical students within IUSM will now be discussed.

The Objective Structured Clinical Examination (OSCE) at IUSM

Medical students from all nine campuses of Indiana University School of Medicine (see Figure 3.1) participate in two OSCEs over the course of each academic year: a formative midterm assessment completed between November and February (depending on the academic calendars and delivery of course content among the campuses), and a summative evaluation at the end of the year around April. All students are required to take both the midterm and final OSCE due to standardization and exam integrity. The examinations occur at the Simulation Center at Fairbanks Hall in Indianapolis, a facility managed by Indiana University Health (Appendix D), and includes Standardized Patient (SP) encounters as well as written documentation stations.

Students receive OSCE scores and feedback regarding their performance within various domains (e.g., communication and interpersonal skills, diagnostic reasoning, and physical examination techniques) on both examinations. Quantitative feedback provided to students includes which specific competencies were accomplished and both Standardized Patients (SPs) and faculty provide written qualitative feedback. Low performing students are identified during the midterm OSCE and receive additional assistance and remediation prior to their final OSCE. The final OSCE uses a combination of norm-referenced and criterion-referenced methods for evaluating student performance. Timeliness of reporting scores depends on the specific examination, with two-weeks for the midterm and up to one month for the final examination depending on the need for students to retest in the event of failing scores (A. Masseria, personal communication, August 15, 2016).

The aggregate final OSCE scores for the first-year, second-year, and third-year medical students who participated in this study served as the 'clinical competence' variable for Research Questions 1 and 2b. Recall that participants were required to login before proceeding to the questionnaire using their Indiana University Central Authentication Service (CAS) credentials to verify identification and provide their electronic signature, signifying acceptance of the data pairing procedure required for this research, and to conform to the Indiana University IRB approval (protocol #1610985662). The Senior Director of Planning, Assessment, and Evaluation in the Office of Medical Student Education (MSE) in Indianapolis assisted with the redaction of identifying information from the performance-based scores.

A description of the first-year, second-year, and third-year medical student

OSCEs within IUSM will now be presented. A detailed breakdown of the specific items

assessed on each of the OSCEs based on the score reports can be found in Chapter 5.

Foundations of Clinical Practice Year One Summative OSCE (FCP Y1 OSCE)

All first-year medical students within IUSM must pass the Foundations of

Clinical Practice Year One Final OSCE (FCP Y1 OSCE). This performance-based

assessment accounts for 20% of the students' final FCP course grade. The FCP Y1 OSCE

is comprised of four sections: Section I Communication and Interpersonal Skills (30% of

overall grade); section II Data Gathering – History and Physical Exam (30% of overall

grade), Section III Documentation (30% of overall grade); and Section IV

Professionalism (10% of overall grade). The total of each OSCE section is converted into

a percentage for that section, then that percentage is multiplied by the weight for that

section. The composite score is the sum of all weighted percentages. Numerical scores

along with feedback from Standardized Patients and/or an assigned faculty grader

comprise the OSCE grade.

Introduction to Clinical Medicine Final OSCE (ICM2 Final OSCE)

All second-year medical students must complete the Introduction to Clinical

Medicine Year Two Final OSCE (ICM2 Final OSCE). The ICM2 Final OSCE evaluates

student performance based on four domains: Physical Exam Skills, Full History and

Physical Documentation and Diagnostic Skills, Communication Skills, and Focused Case

Documentation and Diagnostic Skills. Students rotate through one complete history and

physical station, two focused history and physical stations, and several documentation
stations.

End-Of-Third Year OSCE (EO3Y OSCE)

The End-Of-Third Year OSCE (EO3Y OSCE) is based on the objectives of the
third-year clerkships, consists of ten stations, and is scored on two components: the
Integrated Clinical Encounter (ICE) and Communication and Interpersonal Skills (CIS).
The ICE score is determined as a weighted percentage based on points received for
documentation of post-encounter notes and points received for data-gathering items
related to history-taking questions and physical exam findings across the ten stations. The
CIS score is determined as a percentage based on the points received for performance on
five components (supporting emotions, gathering information, providing information,
making decisions, and fostering the relationship) of the Standardized Patient checklists
across the ten stations.

Statistical Analyses Used to Answer Research Questions 1 and 2

Descriptive statistics were calculated to assess the demographic data from the
third section of the questionnaire in order to describe the samples. Next, reliability
estimates were calculated for internal consistency among participant responses for the
four self-efficacy areas from the first section of the questionnaire (e.g., 'Patient Interview
and Medical History;' 'Physical and Diagnostic Examination;' 'Application of
Knowledge;' and 'Interpersonal Skills and Communication'). The four self-efficacy areas
were found to have high internal consistency (see Chapter 5). Based on the literature

(described below), the four self-efficacy areas were consolidated into a single, averaged composite self-efficacy score for each subject to simplify statistical procedures.

Multiple statistical tests were used to fully explore Research Question 1 ("What is the relationship between ratings of clinical self-efficacy and clinical competence as measured by scores on final performance-based assessments (OSCE) among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?"). After assessing the underlying assumptions, independent samples t-tests were computed to compare composite OSCE scores between the intervention group exposed to HFPS and the control cohorts who were not exposed to this instructional intervention. Independent samples t-tests were also calculated for the average self-efficacy ratings between the two groups. Pearson correlations (r) were computed to investigate the relationships between the average ratings of self-efficacy and OSCE scores within each class level for both groups. Pearson correlations were utilized rather than a rank-order analysis because self-efficacy was computed as the average of several questionnaire items and therefore considered continuous so parametric tests were appropriate. Lastly for Research Question 1, analysis of covariance (ANCOVA) was used to test the combined and independent effects of self-efficacy and group (intervention and control) on OSCE performance for each medical class cohort.

For Research Question 2 ("To what extent do simulation performance scores predict ratings of clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?"), ordinary least squares (OLS) regression analyses assessed the extent of influence that participating in HFPS had on self-efficacy and OSCE performance in second-year medical students at the

intervention campus (IUSM-B). Simulation scores were assigned to IUSM-B second-year medical students by clinical faculty and served as the 'simulation performance' variable in the OLS regression analyses. Similar to Research Question 1, the 'clinical self-efficacy' variable was calculated as the composite score from the average of the items within each of the four self-assessment areas on the questionnaire (Appendix A and Appendix B). All statistical analyses for Research Questions 1 and 2 were performed using IBM SPSS Statistics for Mac OS X, Version 24.0 (IBM Corp., Armonk N.Y., USA).

As explained further in Chapter 5, the previous statistical tests were developed in collaboration with a statistical consultant prior to data collection. After data collection, a smaller sample size was obtained than originally anticipated; however, the statistical tests represent the most appropriate and available methods to answer Research Question 1 and Research Question 2, thus the statistician advised continuing with the original plan and acknowledge that the small sample size violated the statistical assumptions, underpowered the tests, and therefore limits the interpretation of the results (M. Frisby, personal communication, May 17, 2018).

Thus far, the quantitative facets of this research have been discussed. The following sections will be dedicated to the qualitative data that was collected to answer Research Question 3 ("How do first-year, second-year, and third-year medical students and medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?"). The methodology used during the interview process of medical students will be explained first, followed by a discussion of the qualitative research method that was used to analyze the interview transcripts.

Qualitative Interview Methodology used for Research Question 3a

All medical students, including the first-year, second-year, and third-year medical students from the intervention campus (IUSM-B) and the control campuses (IUSM-E and IUSM-FW), who indicated a willingness on the questionnaire to participate in a follow-up interview regarding their clinical skills training (and HFPS training for IUSM-B) and OSCE testing experience were contacted through an email invitation. Given the specific date of the OSCE (see Table 3.3), first-year and second-year medical students from IUSM-B, IUSM-E, and IUSM-FW were invited for the interview portion of this research June 19-20, 2017. Third-year medical students from IUSM-B and IUSM-FW were invited July 14-15, 2017. The interview transcripts served as the data for Research Question 3a.

Follow-up interviews gave students the opportunity to reflect on their performance and re-evaluate their original self-assessment from their questionnaire responses, since students have been found to be less accurate before a criterion then after (Blanch-Hartigan, 2011). Students were informed that interviews could be conducted via Skype, FaceTime, telephone, or in-person based on the preference and availability of the interviewee. The geographically distinct locations of the medical students in this study, coupled with their limited availability from filled class schedules and clinical responsibilities, necessitated the use of multiple interviewing strategies.

Sweet (2002) concluded that the quantity and quality of data obtained through face-to-face interviewing compared to that of telephone interviewing was not noticeably different. However, Irvine (2011) discovered that telephone interviews are shorter than face-to-face interviews, reduced the amount of participant talk, and the absence of visual

cues yielded less detail and elaboration. In contrast to telephone interviewing, videoconferencing using Voice over Internet Protocol (VoIP) technologies (such as Skype and FaceTime) has the advantage of access to verbal and nonverbal cues in real-time (Sullivan, 2012), greater flexibility, convenience, and avoids possible safety concerns with evening interviews (Deakin & Wakefield, 2014). Limitations do exist with this technology as well; technological constraints, such as participant access to a reliable Internet connection, Internet connection speeds, and poor sound and video quality (Sullivan, 2012), as well as disruptive environments may affect the interview flow, interviewee concentration, and subsequent data collection (Deakin & Wakefield, 2014).

All medical students (from the intervention and control groups) who agreed to an interview on the final item of the questionnaire (IUSM-B n=22; IUSM-E n=4; and IUSM-FW n=17) were contacted by email in June or July 2017, depending on the specific campus and year in medical school, which was approximately one month after taking their final, summative performance-based assessment (OSCE). Each participant who indicated a willingness to be interviewed was contacted once, and then those that agreed to an interview after being contacted were subsequently interviewed once.

Specific interview questions can be found in Appendix E. The interviews intended to obtain data regarding perceived performance on the OSCE (asked in Section 2 of the questionnaire) compared to their actual performance on the OSCE, as well as how they typically prepared for the OSCE. Interview questions also related to Section 2 of the questionnaire included an elaboration on the ranking question of educational strategies to learn clinical skills (e.g., HFPS, SPs, part-task trainers, real patients, and computer-based modules). Questions were also asked about SPs, including the student's general

perception of using SPs and if they had ever received contradictory advice, either between SPs or between an SP and their program's recommendations. An elaboration on their choice of the Dreyfus ranking question was also asked of all interviewees.

Those medical students from the control group were asked if they had a chance to work with nursing students at their campus and if they had a chance to practice in a high-fidelity simulation center. Medical students from the intervention campus were asked specific questions related to their experiences within the IUBIPSC. The final question for all interviewees asked if they had any recommendations for how clinical skills (and for HFPS for the IUSM-B medical students) are taught in their program at their campus.

DiCicco-Bloom and Crabtree (2006) explained that individual, in-depth qualitative interviewing is a method to acquire knowledge about unique experiences and perspectives. They recommend semi-structured interviews consisting of predetermined open-ended questions. The preselected questions (Appendix E) helped to guide the general direction of the interview and additional questions emerged from the conversation as the interview progressed.

The practical guide for qualitative interviewing outlined by Turner (2010) was also consulted. For the 'preparation stage of interviewing,' the following occurred: 1. The purpose of the interview was explained to the participant; 2. Terms of confidentiality were addressed; 3. The general format of the interview was explained; 4. The approximate length of time for the interview was indicated; 5. A recording device was enabled with the participant's confirmation of acceptance to being recorded. During the next phase of 'interview implementation,' the researcher was cognizant regarding the following elements as addressed by Turner (2010): 1. Occasionally ensure that the

recording device is functioning properly; 2. Ask one question at a time; 3. Remain neutral since strong emotional reactions may bias the interviewee; 4. Provide transitions between major topics; 5. Focus the interview back to the original questions if off-topic digressions occur.

All medicals student interviews were eventually conducted in-person or over the phone and consisted of answers to semi-structured questions (Appendix E). Each interview lasted approximately twenty minutes (see Chapter 6 for specific interview duration times), and were digitally recorded using an audio device then transcribed verbatim by the researcher, as Merriam (2009) recommended for producing a quality dataset and enhancing validity of the results. Interview transcripts were analyzed following the procedure for the directed approach to QCA, described next, and coded using MAXQDA software, Version 12 (VERBI Software Consult, 2015).

Qualitative Content Analysis (QCA) of Interview Transcripts to Investigate Research Question 3a

Qualitative content analysis (QCA) (specifically, the directed approach to QCA) was used to code all interviews and open-response questionnaire responses conducted during the course of this project. QCA is a specific type of discourse analysis that was formally described in the 1950's as an objective, systematic technique used in communication research (Berelson, 1952). QCA is used to condense large amounts of text into efficient content categories that represent similar meanings (Hsieh & Shannon, 2005; Weber, 1990). It has since been refined and expanded upon, most notably by Krippendorff (2004) and Mayring (2014).

This technique has been said to preserve the strengths of quantitative analysis while allowing for the organic development of qualitative interpretation (Mayring, 2014). Conducting QCA involves an iterative process between the whole and parts of a text to develop a sophisticated understanding of large amounts of data by generating condensed themes or patterns that emerge through coding via a systematic classification process (Graneheim & Lundman, 2004). This precise systematic coding process of QCA also imparts objectivity, ensuring reliability in that another investigator can systematically follow the outlined procedure and obtain similar results (Mayring, 2000). Several approaches and processes have been described within QCA methodology.

Hsieh and Shannon (2005) explained three distinct approaches to QCA: conventional, directed, and summative. Briefly, **conventional QCA** is used to describe a phenomenon in which existing theory or research is limited and the researcher approaches the project without using preconceived categories; **directed QCA** is a more structured process used when research about the phenomenon exists, but may be incomplete or would benefit from further investigation; and **summative QCA** is the most quantitative approach in which usage of particular words or phrases are counted within their context to explore frequency distributions.

The directed approach to QCA was used for this research for several reasons. One of the major benefits to using the directed approach to QCA is the sophisticated understanding that investigators are unlikely to conduct research from a naïve perspective (Hsieh and Shannon, 2005), which is a hallmark in some qualitative designs, such as in constructivist grounded theory methodology (Charmaz, 2014). The author obtained an immense amount of knowledge regarding the implementation, evaluation, and

controversies surrounding the use of HFPS in healthcare education during the literature review (Chapter 2). Therefore, the directed approach provided a framework for the extensive literature review that was conducted prior to this dissertation research commencing. Additionally, the directed approach to QCA was utilized rather than another form of qualitative research (Chen & Teherani, 2016), such as grounded theory (in which the purpose is to develop a theoretical model explaining how a process or action functions) or phenomenology (in which the purpose is to understand the nature of a phenomenon through those that have experienced the event, circumstance, or incident), because several models of learning theories and perceptual phenomena associated with HFPS already exist (see Part V in Chapter 2). Finally, the summative approach to QCA, while also methodical, was too restrictive for this research due to the exploratory nature of the research questions and the overall goals of this research. Therefore, the directed approach provided a framework for analysis while still allowing for flexibility in the analysis process.

The actual steps of the directed approach to QCA outlined by Hsieh and Shannon (2005), as well as the techniques proposed by Mayring (2014), are outlined below, along with a brief description of how each step was implemented for this dissertation research. Further descriptions can be found in Chapter 6, which discusses the qualitative results of this portion of the work.

1. **Formulate the research question(s).** Both quantitative and qualitative inquiries require a concrete, specific research question or questions as a starting point to guide the research process on relevant, practical problems. To investigate the personal experiences of medical students exposed to HFPS, Research Question 3a

was posed, which specifically asked, "How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?" (see Table 3.1).

2. **Identify the sample to be analyzed.** The research design, even if conducting a primarily qualitative investigation involving small samples or a single case study, must develop and describe the sampling strategy and sample size. Although there is little consensus as to the number of interviews needed in order to obtain a representative sample, Merriam (2009) advised that once the same concepts and themes reoccur in the data and emerging findings, then **saturation** has been reached. The sample to be analyzed for this research was medical students who were exposed to HFPS in their curriculum and medical students who were not exposed to this pedagogy. Every questionnaire participant who indicated consent to be contacted for an interview was emailed once at the email address that they provided on the questionnaire. The end result was 21 interviews (see Chapter 6). Although medical students from the control groups with little to no exposure to HFPS were not the primary focus of Research Question 3a, all those students within the control group who indicated a willingness to be interviewed were also contacted in order to obtain a holistic view of the impact, or lack thereof, of HFPS in medical education.

3. **Define the areas of classification and codes to be applied.** Specific units for analysis are identified during the literature review (see Chapter 2), operational definitions are created for each unit of analysis, and preliminary **codes** are constructed. For this analysis, the original codebook of 13 codes created for the

pilot study (Chapter 4), along with the four emergent codes discovered during that pilot study, resulted in a total of 17 codes used as the original codebook (Figure 6.1).

4. **Implement the coding process.** One coding strategy begins by reading through all transcripts carefully, "to obtain a sense of the whole" (Graneheim & Lundman, 2004, p. 108). During the second reading, text relevant to the previously described coding definitions is subsequently assigned codes. The transcripts are reviewed a third time for those passages of text that do not describe a previously created code, and new codes and definitions are developed from the novel text, which are known as 'emergent codes' (Spurgin & Wildemuth, 2016). This iterative, stepwise process was employed for this research: each interview transcript was imported into MAXQDA software, Version 12 (VERBI Software Consult, 2015), initially read through, coded using the codebook described in step 3 during the second round of reading through the transcripts, then read through again looking for emergent codes. Subsequent rounds of reading and analyzing the transcripts further refined the codebook, which is discussed in Chapter 6.

5. **Analyze the results of the coding process.** Continued reviews of the transcripts allow the researcher to refine the interpretation by condensing codes into **categories** (patterns that are directly expressed in the text or derived from them); sometimes, relationships are identified as **subcategories** before condensing into categories if needed; the final step of this processes is to condense the data into a central **theme** or themes. For this research, all codes were reviewed and condensed, subcategories (for the pilot study, see Chapter 4) and categories were

created, and final themes emerged (see Chapter 6 for the specific results of this analysis).

6. **Determine trustworthiness (internal validity).** An organized, methodically guided process of creating a coding scheme with concise definitions and then implementing the coding process must occur to determine if the text is consistent with the interpretation. The detailed coding definitions and condensing process should yield strong inter-coder reliability to ensure credibility, increasing the trustworthiness of the research design and findings. Additional ways to establish trustworthiness include review of the coding scheme and analysis by content experts as well as **respondent validation**, also referred to 'member checks,' in which emergent findings are presented to the interviewees to verify their intended meaning (Merriam, 2009). After transcription of the medical student interviews and data analysis, all interviewees were contacted by email with their specific recording, transcript, and preliminary data analysis excerpt for their review, promoting trustworthiness through respondent validation. As explained in Chapter 6, emails were sent to the 21 interviewees and the author received seven confirmation emails in return; all respondents agreed that the interpretation of their position was accurate.

It is important to note that when utilizing a previously established codebook for another investigation (as was done going from the pilot study of second-year medical students in Chapter 4 to the main QCA study of first-year, second-year, and third-year medical students in this dissertation found in Chapter 6), the codebook may need to be revised to accommodate the new study. Refinement of the codebook by condensing

similar constructs is commonly seen in qualitative data coding, especially when predetermined codes are utilized ("Tips and Tools #18: Coding Qualitative Data," n.d.). Additionally, when condensing codes into categories (or subcategories) using the directed approach to QCA, the same code may need to be incorporated into different categories if the text within the codes represents different meanings. For example, Hsieh and Shannon (2005) explained that a researcher may need to separate a code such as "anger" into different subcategories depending on whom the anger was directed toward. These strategies of the directed approach to QCA were utilized in this dissertation research and are presented in Chapter 6.

Q-methodology to Answer Research Question 3b

Although investigating the impact of HFPS during the first few years of medical school is a worthwhile endeavor, obtaining perspectives from those who have previously experienced HFPS during their medical education and have subsequently graduated, adds another piece to the overall fabric of understanding the impact of HFPS beyond the classroom and into residency training. **Q-methodology** is a technique used to elicit attitudes and beliefs of individuals about a particular subject and has been utilized to investigate medical students (Berkhout et al., 2017; Block, 1994; Hee & Euna, 2016; Valenta & Wigger, 1997), medical residents (Barbosa, Willoughby, Rosenberg, & Mrtek, 1998; Daniels & Kassam, 2013; Fokkema et al., 2014; Wallenburg et al., 2010), and attending physicians (Gaebler-Uhing, 2003), among other populations. However, none of these studies have investigated HFPS using medical residents. Therefore, Q-methodology (also referred to as 'Q-method,' 'Q-technique,' or a 'Q-study') was utilized to investigate

Research Question 3b ("How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?").

First, Q-methodology will be defined and explained in a general context. Then the population, sampling strategies, and recruitment techniques used to obtain the sample for the Q-methodology study will be described. This chapter concludes by describing the construction of the data collection instrument of Q-methodology, known as a Q-sort.

Q-methodology Background

The small population of medical graduates who attended IUSM-B and participated in simulations in the IUBIPSC during the first few years of it opening necessitated the use of an instrument that can extract rich data from a small sample size. **Q-methodology** uses factor analytic techniques to identify the unique and clustered attitudes and beliefs (known as 'viewpoints') among a specific sample of individuals who have experienced the same phenomenon (Paige, 2014). Originally described by William Stephenson in 1935, Q-methodology combines the strengths of both quantitative and qualitative approaches to investigate human psychology by systematically measuring the subjective experience, or intra-individual significance (Brown, 1996; Stephenson, 1935). This method was found to offer more detailed, exploratory insights into underlying structure of attitudes and is a more robust technique when compared to a Likert attitude questionnaire (Cross, 2005; ten Klooster, Visser, & de Jong, 2008). The letter Q was used to distinguish this technique from other conventional correlations, like Pearson's *r*.

Q-methodology is exploratory and assumes a strict, narrow focus to discover subjective patterns among a relatively small sample; it is not used to generalize to a larger

population. Stephenson (1935) explained that the small number of individuals examined allows the researcher to obtain a thorough, in-depth analysis regarding the nature of the various factors. Although there is no definitive minimum sample size for Q-methodology studies, Watts & Stenner (2012) advised that 40-60 participants is sufficient (p. 73). Q-methodology studies focusing within health science literature (such as nursing, medical education, hospital personnel, and faculty) have reported using as few as seven participants (Chinnis et al., 2001), to as many as 122 (McCaughan, Thompson, Cullum, Sheldon, & Thompson, 2002), and 385 participants (Prateepko & Chongsuvivatwong, 2009). Therefore, a Q-methodology study is ideal to research the limited population of medical graduates who not only attended IUSM-B after construction of the IUBIPSC, but also experienced at least one year of simulations within the IUBIPSC.

Q-methodology employs factor analytic techniques, which differs from those in conventional factor analysis. Conventional factor analysis analyzes correlations between variables (by-variant correlations) across a large random sample of people. Q-methodology examines a small number of purposely-selected individuals that become the variables and are grouped into factors (by-person correlations) based on their shared viewpoints (Barbosa et al., 1998; Berkhout et al., 2017; Paige, 2014). The factor analysis used in Q-methodology is similar to cluster analysis, which also mathematically groups people; however, the two techniques are different. They are compared and contrasted below and in Table 3.4.

Both Q-methodology and cluster analysis are similar in that they do not have *a priori* assumptions regarding the number or membership of groups and use responses from individuals to create groups. However, the two techniques differ in how they group

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individuals. In cluster analysis, groups of people are created based on similarities between predetermined variables by the researcher through a survey. For instance, survey questions and responses are created by the researcher and will only yield data regarding the specific questions and responses that are answered by the respondent. In cluster analysis, the groupings of people are based on what the researchers are explicitly looking for; therefore, the findings from cluster analysis are derived largely from the specific questions asked by the researchers and nothing beyond those questions (Dörnyei, MacIntyre, Henry, & Al-Hoorie, 2015).

In contrast, Q-methodology does not use specific survey questions, but instead asks participants to sort diverse statements based on their subjective opinions. Participants are asked to discriminate and sort statements relative to the other presented statements. The participants are then grouped on their broad opinions as a whole based on their sorting pattern of the statements, rather than by the opinions of specific, targeted survey questions like in cluster analysis. Q-methodology is distinguished from other forms of factor analysis because, rather than being concerned with variables or items, Q-methodology is concerned with the ordering of the whole set of items in their holistic configuration (Watts & Stenner, 2012). Therefore, Q-methodology is ideal to investigate the viewpoints of medical residents because it will generate a broad understanding of their personal experiences, rather than their opinions of the author's limited understanding, which is based solely on observations and second-hand accounts instead of through direct, personal experience.

Table 3.4: Comparison of Q-methodology and cluster analysis

	Q-methodology	**Cluster analysis**
a priori **hypotheses**	No	No
Variables	People	People
Data collection instrument	Q-sort	Survey
Method of analysis	Factor analysis	Factor analysis
How individuals are grouped	Results from participants purposively sorting statements based on their personal beliefs	Results from participants answering predetermined questions on a survey created by the researcher

First, the general Q-methodology steps and a brief description of how these were incorporated into the present research will be outlined. This chapter concludes with a complete description of the specific procedure utilized in this dissertation research.

Q-methodology General Procedure

Q-methodology studies follow a sequential procedure to reveal subjectivity (Figure 3.5), and distinct terminology is associated with each step of the process.

1. **Create the concourse.** A collection of opinion-based statements (known as the **concourse**) is synthesized from a literature review, interviews, focus groups, observations, and/or popular texts, such as magazines or televisions programs depending on the particular area to be researched (Watts & Stenner, 2012). The concourse should represent the breadth and depth of a topic under study, similar to data saturation (Paige, 2013). For this study of HFPS, the literature review (see Chapter 2) and observational and interview data from the pilot study (see Chapter 4) were used to create the concourse.

2. **Create the Q-sample.** Next, the statements from the concourse are condensed

    and refined to create a succinct but broad collection of statements, known as the

    Q-sample or **Q-set**. Brown (1980) suggested reviewing the concourse and

    organizing each statement by general subject, which will expose redundancies for

    subsequent elimination. For this research, the concourse underwent a rigorous

    scrutinizing process using several individuals involved with HFPS, including two

    Simulation Coordinators, two physician-faculty members, and one medical

    student exposed to HFPS during their education. The exact procedure of

    condensing the concourse down to the Q-sample for this dissertation research is

    described in more detail in the next section and in Chapter 7.

3. **Participants sort the statements.** Participants are then asked to rank-order the Q-

    sample according to their current level of agreement or disagreement into a

    predetermined bipolar, inverted quasi-normal distribution (Figure 3.6), that

    contains as many cells as Q-statements, and includes two anchors (for instance, –4

    for strongly disagree to +4 for strongly agree). The process of sorting is known as

    Q-sorting, while the final product after the sorting procedure is known as the **Q-**

    sort (Barbosa et al., 1998; Paige, 2015). Described in greater detail below, a user-

    friendly open-source electronic sorting software platform, known as Q-sortware

    (Pruneddu, 2011), was utilized for this research due to its intuitive functionality,

    ease of distribution to medical residents across the country, and open-source

    access.

4. **Analyze the Q-sorts via factor analysis.** The sorted statements are then analyzed

    using factor analysis methods. Each participant's Q-sort undergoes factor analysis

and rotation to derive the factors. Factors represent groups of similarly completed

Q-sorts, in which everyone within a particular factor shares a common viewpoint

concerning the study topic (Chinnis et al., 2001). This research utilized an open-

source, browser-based Q-factor analytic application, known as Ken-Q Analysis©,

Version 1.0.1 (Banasick, 2016).

5. **Interpret the factors.** Finally, supplementary focused interviews are conducted,

inviting participants to expand on their sorting choices and overall experiences

(Brown, 1996), which is then incorporated to interpret the factors for a more

comprehensive understanding of the individual's beliefs. For this research, all

medical residents who indicated that they would be willing to participate in a brief

follow-up telephone interview regarding their Q-sort and simulation impressions

were contacted to enhance the factor interpretations. As explained below, 12

medical residents participated in the study and submitted a Q-sort, of those 12

only six agreed to be interviewed; ultimately only one interview was conducted.

Figure 3.5: Q-methodology project sequence adapted from Ha (2016)

Research question ⟶ Collection of statements derived from the literature, focus groups, interviews, observations, and/or surveys about research topic

Concourse development

Iterative consensus process:
Delete redundancies, condense
similar concepts, review by
domain experts

Pilot test

Define final Q-sample (Q-set)

Recruit participants P-sample (P-set)

Rank-order statements yields the Q-sort

Factor analysis

Factor extraction methods:
• Principal components
• Centroid

Factor extraction

Factor rotation methods:
• Varimax
• Judgmental (manual)

Analyze and incorporate supplementary survey data

Factor interpretation

Figure 3.6: An example of a Q-sort grid for 40 Q-sample statements

Strongly Disagree ⟵ Neutral ⟶ Strongly Agree

| -4 | -3 | -2 | -1 | 0 | +1 | +2 | +3 | +4 |
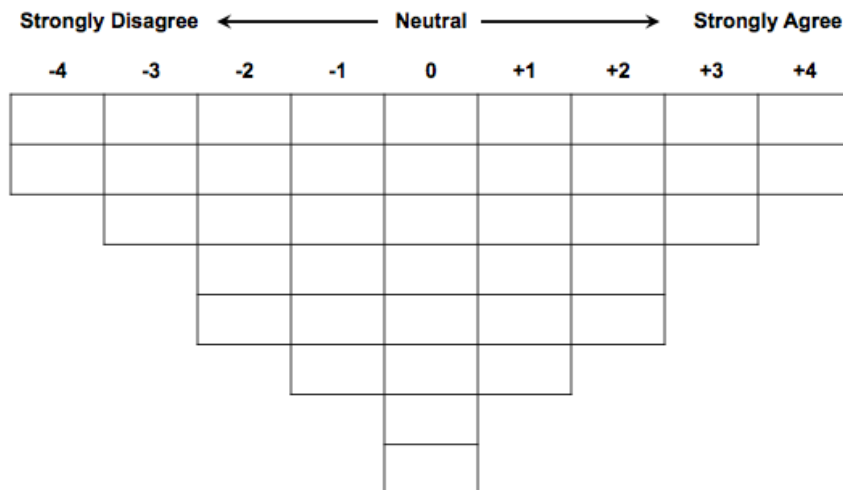
Q-methodology Reliability and Validity

Q-methodology has been utilized for decades and the reliability and validity of this technique has been investigated. The reliability of Q-sorting is verified by a test-retest procedure (usually at one-week and two-week intervals) and intra-individual correlations have been found to be .80 or higher (Akhtar-Danesh, Baumann, & Cordingley, 2008; Brown 1980). Validity of Q-methodology encompasses three facets: content, face, and Q-sorting validity (Ha, 2016). **Content validity** is typically satisfied when domain experts (e.g., faculty and/or Q-methodologists) appraise the statements as to whether the Q-sample is a valid representation of the concourse (Paige, 2013). Verification of **face validity** occurs with modifications to exact wording and phrasing of the statements following expert review and/or a pilot study (Akhtar-Danesh et al., 2008). Finally, **Q-sorting validity** refers to whether the sorting participants can accurately share their perspectives, and is assessed with a pilot study of the final group of statements and member checking during follow-up interviews of the Q-methodology study (Dennis, 1992). These reliability and validity measures were completed for the present dissertation study and are reported in Chapter 7.

The specific Q-methodology process utilized to investigate the impact of HFPS in medical education for this research will now be described in greater detail.

Using Q-methodology to Examine HFPS at IUSM-B

Population, Sampling, and Recruitment of Medical Residents

This Q-study included recent medical graduates from the IUSM-B classes of 2015, 2016, and 2017 (Table 3.5). These individuals were selected for the Q-study

because they experienced HFPS in the IUBIPSC for at least one year during their undergraduate medical education. All of these medical graduates were in residency training at the time of data collection, and were asked to reflect on their simulated training within the IUBIPSC during their medical education, and then sort statements about simulation in the context of their current careers. Understanding their viewpoints may aid in interpreting performance and help to identify the extent to which simulation influences future clinical self-efficacy and ability. Knowing these perceptions about the use of clinical simulation will also ensure that simulation pedagogy is meeting "the unique learning needs of the student population" (Baxter et al., 2009, p. 865).

The IUBIPSC opened January 2013, therefore only those students who had experienced simulations in the IUBIPSC, and had graduated at the time of this study, could be included in the Q-methodology portion of this research. All of the former students within each of the following IUSM-B medical classes were considered the population for the Q-study (Table 3.5): class of 2015 (*N*=6, who stayed in Bloomington for their third year and had access to the simulation center), the class of 2016 (*N*=35), and the class of 2017 (*N*=35). Although the first and second-year medical classes typically consist of 35-36 students at IUSM-B, few medical students stay in Bloomington for their third and fourth years (approximately eight third-year and two fourth-year students), and instead move to complete their final two years of medical education at the Indianapolis campus (IUSM-IUPUI, see Figure 3.1), which has a larger hospital facility. Therefore, only six students from the class of 2015 stayed at IUSM-B for their third year and thus obtained at least one year of experience in the IUBIPSC prior to graduating or moving to Indianapolis. The entire classes of 2016 and 2017 were included because they both

experienced at least one year within the IUBIPSC prior to moving and graduating.

Therefore, former medical students from these three classes attended IUSM-B for at least

two years, participated in simulated clinical experiences within the IUBIPSC for at least

one year, have graduated from medical school, were able to provide their specific

perspectives based on their simulation experiences, and were able to reflect on the

implications of HFPS within the context of their current career.

Table 3.5: IUSM-B populations and samples used for the Q-methodology study

Medical Class Year	Class Size (N)	Contacted	Participated in Q-study (n)	Willing to Interview	Interviewed
2015	6*	4	2	1	1
2016	35	21	1	0	0
2017	35	33	9	5	0

* The class of 2015 included 22 medical students, however only six students stayed in
   Bloomington for their third year, and therefore experienced simulations within the
   IUBIPSC prior to moving into residencies.

Although the IUSM Office of Medical Student Education (MSE) does not

maintain a list of contact information from IUSM graduates, they did assist in locating

the match day lists, which can be found at https://mednet.iu.edu (Accessed September 9,

2016). From this webpage, clicking on "Portals," then scrolling down to "Medical

Students," then clicking on "Events," followed by clicking on "Match Day" will display a

list of names, specialty, and institution for those students who chose to provide their

future contact information to MSE.

MSE then advised the author to conduct a manual Internet search of each resident

based on the match list. This method resulted in finding 40 email addresses. These 40

residents were sent a personal initial email invitation containing information about the

study, a hyperlink to access the Q-sort online, as well as an attached study information sheet (Appendix F). This initial email invitation was followed by two follow-up reminder emails if they did not complete the study. These reminder emails were sent in intervals approximately two to three weeks apart. These individuals were recruited by email to participate in the Q-methodology study in August, September, and October 2017, depending on when the emails were found. Three requests were sent to each participant, until they completed the study, with follow-up emails sent in three phases as recommended by Kochhar (2017): 1. An initial invitation; 2. A second follow-up invitation; and 3. A third and final follow-up invitation.

A request was then sent to the Indiana University School of Medicine Alumni Association with the 36 residents whose email addresses could not be found online. The Director of Alumni Relations sent 32 email addresses (four residents did not have email records) to the Principal Investigator (PI) listed on the IRB approval of this dissertation research (VDO). The PI sent a general email invitation to the 32 residents, however, received a "delivery failure" notification for 14 of these email addresses. Ultimately, 58 resident emails were found.

Additionally, every email to the medical residents of the IUSM-B classes of 2015, 2016, and 2017 asked the participant to forward the invitation email to peers within their medical school class that they are still in contact with for inclusion in this study. This strategy is known as 'network sampling,' which is described under the larger domain of criterion-based selection (LeCompte & Preissle, 1993). Network sampling (also referred to as 'chain,' 'chain-referral,' or 'snowball sampling') asks existing study participants to

refer their acquaintances as future subjects in order to capture the most respondents within the sample (Dillman et al., 2014).

Creation of the Q-sort Used to Investigate HFPS at IUSM-B

As previously mentioned, Q-studies begin with the creation of the **concourse**, a collection of statements from primary sources. For this Q-study examining HFPS, a series of 77 opinion-based statements were collected by the author from a variety of sources including simulation research from the literature review (Chapter 2), previously published simulation studies, and observational data and statements extracted from interview transcripts of second-year medical students regarding HFPS (see Chapter 4). The concourse was reviewed, organized by general subject, and redundancies were eliminated as recommended by Brown (1980). The phrasing of the concourse was edited to align with the following recommendations by Watts and Stenner (2012, p. 62): avoid technical or complicated terminology; avoid double-barreled items containing two or more qualifications; and avoid negatively expressed items, which may introduce a double-negative response that is difficult to interpret.

Following this process yielded a **Q-sample** of 35 statements. Next, a small pilot test (Appendix G) of two Simulation Coordinators, a faculty member knowledgeable about simulation, and a medical student who experienced simulation, reviewed the 35 statements and further refined them for content validity (the completeness of the statements, noting inclusion of all elements within the given topic), face validity (modification of wording and phrasing), and Q-sorting validity (the ease of understanding the statements and subsequently the ability to accurately sort the statements based on

their perceptions). This pilot test yielded the final Q-sample, which consisted of 37 statements (Appendix H).

Traditionally, Q-studies consist of physically sorting the statements written on cards onto a paper Q-sort grid at a large desk. This study used a free electronic sorting software platform, known as Q-sortware, Version 2 (Pruneddu, 2011), unless the participant requested a mailed manual sort option (no medical resident requested this option). The reliability and validity of electronic sorting programs compared to paper-based sorting has been found to be very similar between both methods, although participant satisfaction and understanding of the Q-sort instructions was higher with the electronic version than the paper sort option (Reber, Kaufman, & Cropp, 2000). Data analysis of the Q-sorts, including extraction of factors and axis rotation, was conducted using an open-source, browser-based Q-factor analytic application, known as Ken-Q Analysis©, Version 1.0.1 (Banasick, 2016), and is reported with the results of this portion of the dissertation research in Chapter 7.

This chapter presented the research questions, rationales, and a detailed summary of the methodology used to investigate the research questions. Prior to formulating these research questions, a pilot study was conducted during spring 2016 of IUSM-B second-year medical students (from the class of 2018) regarding their perceptions of HFPS. The methodology and results from the pilot study will be discussed in the next chapter. Then, Chapters 5, 6, and 7 will present the results of the main dissertation research. Chapter 8 concludes this dissertation with evidenced-based recommendations for implementing HFPS, a proposed medical curriculum that methodically integrates HFPS throughout the first two years of medical school, limitations of this research, and future directions.

CHAPTER 4: PILOT STUDY OF SECOND-YEAR MEDICAL STUDENT

PERCEPTIONS REGARDING HIGH-FIDELITY PATIENT SIMULATION

Medical students are exposed to a plethora of experiences in modern medical curricula, including didactic lectures, small group learning sessions, and simulations. Depending on the resources a particular medical school possesses, clinically-based simulations may be incorporated as computer-based programs (Dawson et al., 2000; Salter et al., 2014), isolated body parts for practicing specific skills, known as part-task trainers (Sheakley et al., 2016), and high-fidelity patient simulations (HFPS) that combine sophisticated, interactive manikins with immersive environments (Gaba & DeAnda, 1988). The multitude of available teaching resources to aid students in their acquisition of knowledge helps create a learner-centered environment and cultivates metacognitive awareness (Bransford, Brown, & Cocking, 2000). Therefore, it is important to analyze student observations and reflections of these educational interventions for perceived effectiveness (Landeen et al., 2015; Reilly & Spratt, 2007).

To obtain a deeper understanding of the medical student simulation experience at Indiana University School of Medicine, Bloomington (IUSM-B) and to inform future directions of this dissertation research, an exploratory pilot study was pursued during spring 2016. Over 22 hours of observations were conducted of IUSM-B medical students and nursing students at Indiana University School of Nursing, Bloomington (IUSON-B) who had participated in simulations within the Indiana University Bloomington Inter-Professional Simulation Center (IUBIPSC). Additional observations of medical residents were conducted in the Simulation Center at Fairbanks Hall in Indianapolis (Appendix D).

Following the observations, a series of 11 interviews were conducted from a population of 32 second-year IUSM-B medical students regarding their simulation experience in the IUBIPSC. Note that in contrast to the rest of this dissertation research, this pilot study was intended to be an entirely qualitative investigation into general perceptions of HFPS; thus, statistical analysis of self-efficacy and Objective Structured Clinical Examination (OSCE) scores were not considered for this pilot study (see Chapter 5 for quantitative analysis involving self-efficacy and the OSCE).

This pilot study aimed to investigate a series of broad research questions about the utility of HFPS through a directed approach to qualitative content analysis (QCA). A detailed description of this approach was previously described (see Chapter 3) and is briefly reviewed in the 'Interview Analysis Methodology' section below. The research questions that guided this pilot study were as follows:

1. What do IUSM-B second-year medical students view as the most beneficial aspects about participating in HFPS?

2. How do these second-year medical students perceive the realism (fidelity) achieved within the IUBIPSC?

3. Do these second-year medical students believe they have sufficient opportunities to participate in HFPS at IUSM-B?

4. Do the second-year medical students prepare prior to participating in HFPS in the IUBIPSC, and if so, what form does this preparation take?

5. After reflecting on their experiences with HFPS, do IUSM-B second-year medical students have recommendations for how future simulations are conducted?

6. What advice do IUSM-B second-year medical students have for future IUSM-B medical students regarding their simulation experience?

Sampling and Recruitment

This pilot study used a convenience sample of volunteers recruited from a population of 32 second-year medical students from the IUSM-B class of 2018. All students had participated in several HFPS experiences, beginning in the first year of their medical education curriculum (refer to Chapter 3 for the specific amount and types of HFPS medical students participate in during their education at IUSM-B). Subjects received an initial invitation email and two follow-up emails (distributed approximately one week apart from each other) between April and May 2016 to participate in the study. Eleven medical students responded to the interview request and interviews were conducted on May 5, 2016 (34% response rate). Regarding response rates for educational research interviews, Opie (2004) explained, "there are no hard and fast rules" (p. 116); however, a response rate of approximately 10% (calculated from the author's recommendation of conducting 10 interviews for 100 questionnaires received) is practical as far as the time needed to conduct in-depth, quality interviews, as well as the time required to analyze the interview transcripts.

Interview Methodology

Individual face-to-face interviews were performed by the researcher following the recommendations for in-depth interviews outlined by DiCicco-Bloom and Crabtree (2006) and the protocol for qualitative interviewing advised by Turner (2010). Both

protocols are explained in more detail in Chapter 3 of this dissertation. Each semi-structured interview occurred on the IUSM-B campus, lasted an average of 20 minutes, and consisted of answers to open-ended questions (the initial questions for the semi-structured interviews may be found in Appendix I). Additional questions that were asked emerged from the dialogue between the researcher and the interviewee.

All interviews were digitally recorded using an audio recording device and transcribed verbatim by the researcher. Merriam (2009) recommended this method to produce a quality dataset and acquire, "the intimate familiarity with your data that doing your own transcribing affords" (p. 110). Transcribing all of the interview data manually and reading through the entire transcript checking for accuracy also enhances the internal validity of findings (Hsieh & Shannon, 2005).

Interview Analysis Methodology

The procedure for the directed approach to qualitative content analysis (QCA), which is briefly described next and further explained in Chapter 3 and Chapter 6, was used for this investigation. Interview text from second-year medical students regarding their perceptions about participating in simulations at the IUBIPSC served as the 'unit of analysis' and pre-established codes (Table 4.1) were compiled during the literature review stage (see Chapter 2) to serve as the initial template during the coding process. All transcripts were coded using MAXQDA software, Version 12 (VERBI Software Consult, 2015).

Table 4.1: Codebook for second-year IUSM-B medical student interview transcripts using the directed approach to qualitative content analysis (QCA)

Code	Definition / Coding Rule
1. Think clinically	Obtaining the mental framework of a physician by thinking critically, reasoning through a case while under pressure, and making quick decisions (Gordon et al., 2001)
2. Practice to learn from mistakes	Practice to gain knowledge and develop skills by learning from mistakes (Bradley, 2006)
3. Feedback	Prompt evaluation of learner performance during the debrief, intended to recalibrate their perceived confidence levels toward a more accurate self-assessment of ability for improved clinical performance (Moores & Chang, 2009)
4. Safe space	Exposure to a variety of clinical scenarios in a supportive environment (Henneman et al., 2007)
5. Preparation for improved patient safety	Developing knowledge, skills, and attitudes to align with the "first do no harm" Hippocratic Oath for future practice with live patients (Ziv et al., 2006)
6. Communication	Clear language, closed loop communication, patient education, use of team input, and body language (Reising et al., 2011)
7. IPE (teamwork/roles)	Collaboration among two or more professions deliberately learning from and working together, gaining knowledge, practical skills, and improved communication for effective team healthcare management (Interprofessional Education Collaborative Expert Panel, 2011)
8. Experiential/ immersive	Recreation of the modern physical and mental task environment that requires hands-on manipulation (Gaba & DeAnda, 1988)
9. Psychomotor skills	Procedural skills requiring dexterity and/or muscle memory (Bradley, 2006)
10. Enhanced fidelity	The extent to which delivery of an intervention reliably imparts realism and authenticity (Mowbray et al., 2003)
11. Stress and performance anxiety	Experiencing stress from pressure and demands but learning how to manage emotions that impede task performance and decision making (Driskell & Salas, 1996)
12. Integration	The incorporation of foundational basic sciences with clinical applications for improved understanding and knowledge retention (Gorman et al., 2015)
13. Period of acclimation to the simulated environment	Learners must have the opportunity to engage in multiple simulations until they acclimate to the novelty and technology (Dotger et al., 2010)

The **directed approach to qualitative content analysis (QCA)** was used for this pilot study, which is a systematic method of discourse analysis. Three approaches to QCA have been described, including conventional, directed, and summative (Hsieh & Shannon, 2005). The directed approach was selected for this research because of the flexibility that it provides in that new codes can be added to the codebook (known as 'emergent codes' and are described below), yet the directed approach maintains a systematic coding process with established codes and accompanying definitions or coding rules. This methodical process is a benefit of QCA, ensuring reliability in that another investigator can systematically follow the outlined procedure and obtain similar results (Mayring, 2000).

In QCA, **codes** are established prior to analysis based on a review of the literature. These codes are labels and represent the smallest unit of meaning (Graneheim & Lundman, 2004). The codes are assigned to words, phrases, and short segments of the transcripts based on the code definitions and context of the transcript in which the coded information is found. Continued analysis of the transcripts may reveal passages of text that do not fit into the preexisting codes; these segments are assigned a new code (known as **emergent codes**) and subsequently added to the codebook (Spurgin & Wildemuth, 2016). All codes (initial and emergent) are then condensed, or grouped, to reduce the data and aid in interpretation. These refined groupings are known as **categories**, which are common patterns or domains that are rooted within the data (Bengtsson, 2016). **Subcategories** may be created to aid in the interpretation of broader categories, although the creation of subcategories is not necessarily required in QCA. Lastly, the categories are condensed and an overall **theme** (or multiple themes) is identified, which is a higher-

level of categorization that captures the underlying meaning of the entire data set (Graneheim & Lundman, 2004).

Ethical Approval

This research was reviewed and granted exempt status by the Indiana University Institutional Review Board (protocol #1604625706). All study participants were provided a study consent form (Appendix J), with details regarding the purpose of the research, their voluntary participation in the study, a reminder that their participation or lack thereof would not affect their course grades or standing, and that they could withdraw from the study at any time without penalty. The researcher collected signed and dated consent forms from all of the study participants prior to conducting the interviews.

Results

Specific results related to the six research questions will be described first. The results from the original codebook (Table 4.1) will be presented next, followed by the four additional emergent codes that were also identified from the transcripts. The results of how those codes were condensed into four subcategories, and then how those four subcategories were condensed into two main categories is then presented. Lastly, the results from how the two main categories were condensed into one overall theme will be described. This chapter concludes with a discussion of the codes, subcategories, main categories, theme, and limitations.

Results from the Research Questions

Research Question 1 asked, "What do IUSM-B second-year medical students view as the most beneficial aspects about participating in HFPS?" The results of this question were broad and can be found within all codes (except two of the four emergent codes), and include: Code 1: Thinking clinically; Code 2: Practice to learn from mistakes; Code 3: Feedback; Code 4: Safe space; Code 5: Preparation for improved patient safety; Code 6: Communication; Code 7: IPE (teamwork/roles); Code 8: Experiential/immersive; Code 9: Psychomotor skills; Code 10: Enhanced fidelity; Code 11: Stress and performance anxiety; Code 12: Integration; Code 13: Period of acclimation to the simulated environment; Emergent Code 1: Role of the Simulation Coordinator; and Emergent Code 2: Preference for simulators over Standardized Patients (SPs). Each of these codes are described in more detail later in this chapter. For example, medical student interviews regarding the benefits of participating in HFPS included the ability to practice clinical skills (MS2-10) and build their patient care routine (MS2-03), all within a psychologically safe environment while obtaining crucial feedback (MS2-04).

[MS2-04]: "I think trying to work through an actual clinical scenario has been helpful. I think had we not had that experience it would be more of a shock going into third year and really not knowing like, even just to look at vital signs on a monitor, it's just not things we do, we're just so use to just reading through a book."

[MS2-05]: "I think getting use to like a high-pressure, high-stress situation [was the most beneficial part of simulations]."

[MS2-08]: "I think learning how to approach patient care was helpful and you walk into a room, what do you do? Because it's kind of awkward, you don't know what's going on. So it was nice to establish kind of a pattern you can follow every time and get feedback on that."

Research Question 2 was related to the fidelity, or realism, of the simulated environment and scenarios presented within the IUBIPSC, and asked, "How do these second-year medical students perceive the realism (fidelity) achieved within the IUBIPSC?" The results of this question are captured in Code 10: Enhanced fidelity, and is described in detail later in this chapter.

Research Question 3 looked into the number of simulated events offered to medical students asking, "Do these second-year medical students believe they have sufficient opportunities to participate in HFPS at IUSM-B?" When asked about the number of simulated clinical experiences offered, students were divided. Almost half of the interviewees (45.5%) desired more simulation opportunities, acknowledging that it enabled them to gain practical experience (MS2-04; MS2-10) and directly reminded them of their original desire to attend medical school (MS2-05; MS2-09). However, many interviewees explained that time constraints and immense expectations surrounding school and national standardized testing made them feel that the amount of simulations offered was adequate (MS2-01; MS2-02; MS2-03; MS2-06; MS2-07; MS2-08; MS2-11).

Research Question 4 asked, "Do the second-year medical students prepare prior to participating in HFPS in the IUBIPSC, and if so, what form does this preparation take?" Role-playing was a widely used technique among the medical students in this study to practice preparing for a simulation. Medical students described their role-playing activities as not only doctor/patient (MS2-07), but also as doctor/nurse to prepare for interprofessional education (IPE) simulations (MS2-01).

[MS2-07]:   "I would act like the patient, he would act like a doctor, and we would go through and like quiz each other."

Internet searches were also commonly cited as preparatory methods for simulation, including reading electronic clinical databases for physicians (MS2-06; MS2-08; MS2-11), and watching videos of similar simulations (including watching nursing simulation videos). Medical students also described hypothesizing outcomes and mentally constructing various scenarios that they may encounter during the simulations (MS2-01; MS2-03; MS2-05).

> [MS2-05]: "I would kind of make an outline of how I thought things should go in my head, and then you know if, the simulations then kind of throw, throw at you different things and things that you don't expect…having prepared kind of a basic outline I think made it easier to kind of always come back to that."

Preparation strategies for simulations of IUSM-B medical students and the amount of time devoted to these activities ranged from almost no preparation to two or more hours, with different perceived advantages. While all other interviewees spent time (anywhere from 30 minutes to four hours or more), either practicing their routine aloud by themselves and independently studying online or preparing with other medical or nursing students, one medical student (MS2-04) reflected on their lack of preparation as an attempt to keep an open mind for possible differential diagnoses during the actual simulation.

> [MS2-04]: "I honestly think some of the ones I did better on, I didn't prepare as much because I would prepare so much for, like you know, the six potential diagnoses that I wasn't open to other things."

Used to capture recommendations and constructive criticism regarding the simulations conducted at the IUBIPSC, Research Question 5 asked, "After reflecting on their experiences with HFPS, do IUSM-B second-year medical students have recommendations for how future simulations are conducted?" and Research Question 6 asked, "What advice do IUSM-B second-year medical students have for future IUSM-B medical students regarding their simulation experience?" As for recommendations, the fidelity of the patient manikin was called into question by some students (MS2-02; MS2-04; MS2-10), and the predictable nature of the simulations coupled with certain unrealistic elements of the simulation were noted as things that could be improved upon, and is discussed more under the 'Emergent Codes' section of this chapter. One medical student (MS2-06) suggested continuing IPE simulations, as it prepared them for their future roles.

[MS2-06]: "[I would suggest] keep it with the nursing school as far as having them work with those teams. I really think that prepares you a lot for what you are going to experience in the future."

Regarding advice about HFPS for future first-year medical students, many of the second-year medical students interviewed during this pilot study advised the following: practice prior to the simulations to develop a routine for the actual simulation scenario (MS2-07; MS2-08; MS2-10); incorporate more simulations into the curriculum; increase the duration of the simulation events as some students felt rushed (MS2-04; MS2-10); and prepare with their nursing students to develop solid teamwork skills to display during the simulation.

[MS2-06]: "I would suggest just working with your team, getting comfortable working with each other and communicating, using each other's names and having a conversation where you kind of think out loud. Whereas, it's not so much individual work, really incorporate the knowledge of the whole team rather than just trying to do it all yourself."

Results from the Codebook

First, the results from the original thirteen codes will be presented as they are listed in the codebook (Table 4.1). The four emergent codes that were identified during the analysis will then be discussed.

Code 1: Think clinically

All 11 interviewees stated that simulations at the IUBIPSC provided an opportunity for them to think clinically, obtain real-world experience, and/or prepare them for their third-year clinical rotations. Many interviewees expressed gratitude about participating in the simulations, explaining that the experiences made them think and feel like physicians, reminded them why they chose the profession, increased their feelings of confidence, and believed that HFPS foreshadowed their future clinical experiences. Several students also mentioned that participating in simulations helped them learn to keep an open mind when formulating differential diagnoses.

[MS2-03]: "I think it was just an enjoyable experience, I think it was good preparation and it was a good reminder of what we're working towards."

[MS2-04]: "I think [simulation] was very helpful, and kind of thinking quickly in a clinical setting instead of just reading a test question and being able to think about it for a few minutes. Kind of more on the spot."

[MS2-08]:   "[The simulation routine] gives you the structure that you need…learning what to say first, what to say next, you don't miss anything important…learning to work in the framework makes sense and something we can take to third and fourth year, especially if we were in a situation we're not sure what else to do, at least you can go through the steps you've already learned."

[MS2-09]:   "It felt like it was real life in the sense that it wasn't just book stuff, it felt like I was actually being a doctor so to speak…we learn a lot from it and we just, that's exactly what we want to do in the future."

[MS2-11]:   "Getting real-world experience, so I don't feel so bad going into third year or at least now I'm more like, confident about what I'm doing or less anxious."

Code 2: Practice to learn from mistakes

This code related to the ability for learners to practice skills and techniques from their failures, and four out of 11 interviewees commented about this code. One medical student agreed that learning from mistakes without being penalized for failure was a main benefit of participating in simulations during their medical education.

[MS2-04]:   "I think [simulation] is a good way to just kind of practice clinical stuff where there's not going to be a huge consequence if you don't do great, but you still learn a lot."

Gaining practical experience through mistakes to transcend beyond the simulation room into their future clinical practice was also claimed to be a benefit of the IUBIPSC.

[MS2-11]:   "…focus on using the sim lab to actually practice things is great."

Code 3: Feedback

Feedback, in the form of the post-encounter debrief (MS2-07), grades (MS2-04), or from the patient manikin presentation itself (MS2-01; MS2-06; MS2-10), allowed learners to gain knowledge during the simulation, and was explicitly mentioned by six of the 11 interviewees. All medical students received immediate feedback from physician-faculty during the debrief immediately following the simulation regarding their performance and areas to work on for improvement in the future. During the debrief, physician-faculty also elicited the medical students' thoughts and general perceptions regarding how they believed they performed during the simulation. Medical students noted that this immediate feedback was helpful, encouraging, and explicitly made their perceived and actual competence apparent (MS2-05; MS2-08).

[MS2-05]: "I really enjoyed them all [the simulations] and I liked that we got feedback right away."

[MS2-08]: "[My advice for future first-year medical students is] to just do your best in the first [simulation] and then build on the feedback from there."

Code 4: Safe space

This code differs slightly from Code 2: Practice to learn from mistakes, in that the 'safe space' afforded by HFPS induces less psychological stress for learners, and three interviewees commented on this safe space. Although one may practice and learn from mistakes (as noted in Code 2), this code captures the safe environment, in which students can practice in to learn from mistakes without harming real patients.

[MS2-04]: "It's a safe environment to fail and you're not being penalized for it so you actually are able to learn from those failures."

Code 5: Preparation for improved patient safety

The rushed nature of the simulated scenarios, coupled with the high fidelity of the IUBIPSC, yielded both positive and negative attitudes from the interviewees. The positively coded segments are discussed within this code, while the negatively coded segments are discussed later in this section under Code 11: Stress and performance anxiety. Segments of the nine of the 11 interviews coded as 'positive attitude' were those that noted the stress accurately portrayed what they will encounter in real-world scenarios; therefore, obtaining practice thinking under pressure during the simulations was effective preparation for the medical students to safely work with real patients in the future.

[MS2-06]: "…even though it's pretend you're still being put into a situation of 'ok, I'm going to throw this scenario at you and using the knowledge that you learned over the past couple of weeks, via bookwork, now you have to put all that together to try to cure this patient.'"

Code 6: Communication

Practicing essential communication skills was cited as a major benefit to participating in HFPS among four of the 11 second-year medical students interviewed. Communication came in the form of interviewing and educating the manikin (with the Simulation Coordinator acting as the patient by using a microphone embedded in the manikin), as well as communicating as a healthcare team during IPE simulations. Medical students not only recognized that the simulation offered an opportunity to

practice their communication skills with the nursing students, but they were also

cognizant of the need to develop this communication early in their medical careers.

[MS2-03]: "…the idea of working within our IPE was good for the purposes of establishing communication and learning how we need to communicate with each other."

[MS2-07]: "I think it's good they put an emphasis on communication. I think it's something that happens but you don't actively think about and maybe you get into bad habits, like once you're actually working clinically."

Code 7: IPE (teamwork/roles)

All medical students interviewed during this pilot study acknowledged that

working with the nursing students during interprofessional education (IPE) HFPS was a

valuable learning experience at the IUBIPSC.

[MS2-05]: "We talked through things and kind of, delineated whose role, delineated our roles, you know, if [the nursing student] would ask certain questions, then I would perform certain physical maneuvers or things like that. So we kind of made sure we kind of knew what we were each responsible for, so I think that was helpful, I think it just made us more calm."

[MS2-06]: "…I would talk about [the possible simulation case presentation] with my nurses and we just kind of outlined a plan as far as how we would attack the situation, who would be talking at what time and, who would handle measurements throughout the simulation, and yeah, just outlined a game plan and then just execute it once we got into the simulation lab."

[MS2-07]: "It was a good experience to work with the nurses and, I don't know, get a different perspective."

[MS2-11]: "We would meet like 30 minutes before the sim and go over like different scenarios and how to treat it and who would be in charge of what."

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The acknowledgement of future demands of the healthcare team was a recurring

concept. Even though they were only second-year medical students, the interviewees in

this study recognized the collaboration required and various roles necessary for a high-

functioning multidisciplinary healthcare team to provide quality patient care.

[MS2-03]:   "I think we got to a point where we were really comfortable
              with each other and we knew the roles that we would
              have."

[MS2-04]:   "I think it was definitely helpful working with the nurses,
              kind of figuring out how to work as a team and I could
              definitely tell by the end of the simulations that we had
              kind of learned how to work together a lot better and things
              were a lot more cohesive."

[MS2-07]:   "[My IPE team] got along well and I thought it was also
              good to simulate, in the sense of what it would be like in
              real-life working with other people, having to work on
              patients as a team."

[MS2-10]:   "[Working with the nursing students] was very cool as
              well, just again it kind of really simulates the real-world
              experience. So some of my favorite ones were when the
              nurses would go in first and then they would have the
              medical student come in second. [The nursing students]
              have to do kind of a patient hand-off situation, background,
              assessment…and I think that really was again, more like
              what we will experience in our future years."

Although the communication aspect of the healthcare team dynamic was

emphasized, other components of teamwork surfaced during the interviews, including

interdisciplinary patient care management, cultivating a team mentality, and instilling

attitudes of respect among different healthcare professionals.

[MS2-10]:   "One of the things that our preceptor always says is
              medicine is a team sport, so you're using everyone and a lot
              of times when you're in a simulation alone, you know, it's

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just you that has to be thinking through things, but it was so
nice, because there were plenty of times that my nursing
student would say, 'Hey, we should do this next. How
about this?' Like, it was kind of fun to have other people
see it from a different lens and think of things that you
wouldn't think of and I think that often kind of contributes
to the patient's care."

Code 8: Experiential/immersive

Over half of the medical student interviewees (7 interviewees out of 11) explained

that the advanced technology used in the IUBIPSC and the immersive, hands-on

environment led to believable patient case scenarios and enhanced their learning

experience. The interviewees described benefits while participating in HFPS, such as

learning how to interpret vital signs on a monitor while caring for the patient manikin

(MS2-04), the ability to physically solve medical issues gaining valuable realistic clinical

experience (MS2-07), thinking actively for themselves, and physically going through

concepts that they learned during lectures (MS2-10). When asked to compare their

simulation experience to a computer-based simulation used for their advanced cardiac life

support (ACLS) training, medical students overwhelmingly preferred the immersive

environment of the IUBIPSC to sitting in front of a computer screen interacting with the

ACLS learning module.

[MS2-07]:   "I think in the lab you get more out of that. I feel like I
             remember stuff better when I physically am using my
             hands and doing things and checking physicals than just
             like clicking the button."

[MS2-10]:   "So, to compare, we actually had to do about five to six
             hours online in simulations for our ACLS certification and
             it was one of the more passive, meaningless things I've
             done, unfortunately…I mean again you're just clicking
             buttons, you're looking for an answer that is already there.

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You're not thinking actively for yourself and physically
going through things."

Code 9: Psychomotor skills

HFPS is a method to develop and improve psychomotor skills, hand-eye

coordination, and muscle memory for procedural tasks and basic clinical proficiencies.

Three medical students in this pilot study noted these skills while participating in

simulations at the IUBIPSC (MS2-04; MS2-07; MS2-10). Although specific skills were

not cited in the interview transcripts, such as central venous line insertion or intubation,

the basic idea of hands-on skills training that the simulations provided was apparent to

these medical students.

> [MS2-04]: "Grades aren't what's important, it's my clinical skills and understanding what I'm doing and being able to apply it to next year."
>
> [MS2-10]: "…there's something to be said about muscle memory. You learn by actually doing something rather than clicking a button."

Code 10: Enhanced fidelity

The importance of fidelity to suspend disbelief while participating in the

simulations was mentioned during eight interviews. The realistic environment, high-

fidelity patient manikin (such as observing physiologic signs like tachycardia or pupil

dilation while examining the patient manikin), real medical supplies and equipment, as

well as the psychological fidelity (the degree to which a learner perceives the

believability of a simulation) were acknowledged by second-year medical students in this

study (MS2-05; MS2-08).

[MS2-01]: "It makes it a lot better when you can actually hear the breath sounds or you see that the patient's eyes are dilated when they shouldn't be."

[MS2-06]: "I thought the sim lab as far as the manikin and all the technology and stuff that they had is great. I felt like it really simulated the actual hospital atmosphere even though it's a manikin, it still had great pulses, it could pretty much, any type of heart rhythm or presenting symptom that you would see out of a certain disease, it could simulate it."

[MS2-07]: "I think the advantage to being in there is it kind of feels a little bit more real."

[MS2-08]: "You know it's fake but they do a good job of making it real enough. You still feel stressed, you still feel the pressure. The dummies are pretty impressively good, like mechanically, so I think it still feels as real as it can."

[MS2-10]: "The whole room does kind of look a lot like an actual hospital room, it has just about everything you can need and I really think that kind of helps to get you in the right mindset and atmosphere."

Some students also expressed feelings of how the realistic simulated environment and high-fidelity patient manikin (which not only displayed pathological signs and symptoms but also responded realistically to various interventions that the students performed on the manikin) led to less things that they had to imagine and mentally construct. These high-fidelity elements freed cognitive capacity for the students to focus on caring for the patient manikin.

[MS2-03]: "…[the SimMan 3G] made fewer things that we had to fake going through. It was, it made it much more life-like."

[MS2-10]: "There was one of the simulations where I was interviewing the patient [manikin] and then saw sweat perspiring out of their forehead and everything, it was kind of cool the things that you are able to pick up on."

[MS2-11]: "So like the pulses and having [the Simulation Coordinator] talk over the microphone acting as the manikin is great. The more realistic it is, the better."

Code 11: Stress and performance anxiety

As was mentioned under Code 5: Preparation for improved patient safety, the fast-paced scenarios encountered during simulations, coupled with the quotes from Code 10: Enhanced fidelity, experienced within the IUBIPSC, yielded both positive and negative attitudes. Those segments of interview that were coded as 'negative attitude' were six students who explained that they experienced diminished performance, either from immense stress, feeling rushed through the scenarios, or feeling intimidated by the realism of the scenarios. Four students explained that this hindered them from efficiently thinking through the scenario leading to feelings of frustration and anxiety.

[MS2-01]: "It's hard because you, sometimes you just feel so dumb in there, you're just like sitting there and you're trying to think of what it is, and [the physician-faculty member] is looking at you…you just blank, and it's hard and difficult."

[MS2-04]: "It did feel like sometimes it was rushed…I think the crunch for time can be kind of frustrating."

However, two interviewees in this study explained that while they were stressed, they believed that the stress added an element of realism that they appreciated experiencing as students in preparation for their future careers.

[MS2-05]: "I really did feel like I always learned a lot from [HFPS] and they were like stressful but I always felt like, you know, kind of like a doctor coming out of it."

[MS2-10]: "[The simulation] was a bit nerve-racking and I think that was kind of good to simulate the nervousness even though

you're talking with the manikin, but it's still, it felt very real."

Code 12: Integration

The simulations at the IUBIPSC helped medical students to reinforce learning objectives and provided pragmatic examples of theoretical content. Eight of the students commented during the interviews that they preferred simulations occurring at the end of each 'block of course material' so that they had some foundational knowledge to successfully work through the case (MS2-01; MS2-02; MS2-04; MS2-05; MS2-07; MS2-08; MS2-11).

[MS2-03]: "I like the idea of taking the concepts we're learning in class and actually being able to practice it and do something practical with it, and it was very pragmatic."

[MS2-08]: "I think doing them every block was helpful. I liked doing it with the subject material we had. You didn't feel quite so lost."

Code 13: Period of acclimation to the simulated environment

To obtain the most educational benefit from HFPS, learners must be repeatedly exposed to the simulation environment in order for them to acclimate and adjust to the novelty of the technology and simulation routine (Dotger et al., 2010). Consistent with this recommendation, almost all of the medical students interviewed (9 out of 11) explained that they required at least a few simulations in order to adjust to the realistic room, view the plastic manikin as their patient, learn how to navigate the touchscreen monitor, construct their patient interview routine, and harness their ability to verbally articulate their thought processes.

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[MS2-05]:   "I think kind of the first couple times, you do have sort of brain lock and you, it's harder to kind of think through things in a calm way and I, definitely by the end, I felt that I much improved there."

[MS2-07]:   "The first sim I did, I didn't have a good, like I didn't go in knowing that I was going to do this and then this…I went out and talk to [the physician-faculty member during the debrief] and he was basically like 'This was disorganized and these are the things you need to do to improve.' And the second time I prepared…the sim cases went a lot more smoothly."

[MS2-08]:   "It's kind of hard going into your first one and you know you're doing the best you can and then look at the feedback."

[MS2-10]:   "It is a little awkward at first because you know you're being evaluated, there are a hundred different things running through your mind…I was fumbling from thing to thing."

Now that the results from the original thirteen codes have been described, the results from the four emergent codes will be discussed.

Emergent Codes

A benefit of using the directed approach to QCA is the iterative process allows for flexibility when adding codes to the existing codebook (Hsieh & Shannon, 2005). **Emergent codes** are additional codes that are discovered within the data as analysis and coding proceeds that were not initially identified in the development of the original coding scheme (Zhang & Wildemuth, 2016). During the analysis, four emergent codes were identified that were not previously listed in the original codebook (Table 4.1). The four emergent codes were labeled as: 'Role of the Simulation Coordinator', 'Preference

for simulators over Standardized Patients (SPs)', 'Predictability and technology limitations', and 'Impact of education research'.

Emergent Code 1: Role of the Simulation Coordinator

The IUBIPSC employs one full-time Simulation Coordinator, who conducts all of the simulations for both the School of Nursing and the School of Medicine. Four interviewees explicitly commented that the Simulation Coordinator infused the scenarios with authenticity and enhanced the fidelity of the simulations. Statements mentioned the tonal qualities projected through the manikin by the Simulation Coordinator and the embodiment of the Simulation Coordinator as the patient that helped to convey a sense of realism for the medical students.

[MS2-03]:   "…also [the Simulation Coordinator] does a really great job of eliminating barriers because I think she just kind of embraces the role and so as soon as the student does too, then it's just off to the races."

[MS2-05]:   "I mean I think just because of the real voice umm, you know [the Simulation Coordinator] was great at expressing concern, you know, I could hear different like, inflections in [the Simulation Coordinator's] voice and it made a big difference…it really added to the experience and made it more realistic."

[MS2-08]:   "[The Simulation Coordinator] and [the physician-faculty member] do a really good job. I think they're part of the reason the program is so good and that I liked it so much and if it would have been less well-run, it could be something that was not as helpful."

[MS2-11]:   "I think as realistic as you can make it, the better that it is. So like the pulses and having [the Simulation Coordinator] talk over the microphone acting as the manikin is great. The more realistic it is, the better."

Emergent Code 2: Preference for simulators over Standardized Patients (SPs)

Standardized Patients (SPs) are individuals trained to portray a patient's specific

medical history and set of symptoms (Barrows, 1993; Dotger et al., 2010). SPs are used

for training students and healthcare providers and are also incorporated into performance-

based examinations, such as the Objective Structured Clinical Examination (OSCE).

While comparing their experiences with the manikins in the IUBIPSC to instances when

they were exposed to SPs, two interviewees explicitly indicated a preference for learning

with the high-fidelity manikins over SPs.

> [MS2-05]:   "I almost found it easier to kind of be compassionate and
> be more interactive in the simulation versus like, a
> Standardized Patient who I know is like faking, you know?
> And so I felt like I was faking back."

> [MS2-08]:   "…which is weird because it's a dummy, but in some ways
> it's less distracting than having a real patient who's a fake
> patient, like a real human."

Emergent Code 3: Predictability and technology limitations

Simulation centers resemble a staged performance with standard narratives played

for all students within a particular cohort. The predictability and inaccurate manikin

presentations from possible equipment malfunction or software delays in some

simulations were drawbacks identified by six interviewees as an emergent code in this

pilot study.

> [MS2-04]:   "I do think there were sometimes where the symptoms
> wouldn't match up with the normal presentations that we
> learn [due to equipment malfunction or delay]."

> [MS2-08]:   "…everyone basically knew the dummy was going to
> code."

[MS2-10]:   "Normally you can try to shake the patient's hand [but you can't with the plastic manikin]."

Emergent Code 4: Impact of education research

Finally, two interviewees mentioned the educational research that infiltrates the simulation center. Several education researchers from multiple departments are commonly found in the IUBIPSC to investigate aspects of HFPS. The medical students are also expected to complete a six-question survey at the conclusion of every simulation intended for the Simulation Coordinator's knowledge regarding their perceptions of the simulation event. These education research factors were acknowledged by some students and may have led to survey fatigue or may have had a slight negative impact on their overall experience within the IUBIPSC.

[MS2-10]:   "I felt there was more box-checking going on from an administrative stand-point…just kind of seemed like an excuse to have them do research on our nursing student teams and us or something."

Thus far, the codes (both original and emergent) have been discussed. The following section will describe the creation of subcategories, main-categories, and the overall theme that emerged (see Table 4.2).

Table 4.2: Evaluation of second-year medical student interview transcripts, including subcategories, main categories, and theme (see Table 4.1 for the definition/coding rules for the thirteen original codes)

Code (emergent codes indicated)	Exemplary Quote	Subcategory	Main category	Theme
1. **Think clinically**	MS2-04: "…thinking quickly in a clinical setting instead of just reading a test question and being able to think about it for a few minutes. Kind of more on the spot."	Importance of safely gaining experience and developing a structured routine for future practice	HFPS safely prepares students to think and behave like physicians to contribute to an efficient healthcare team	When strategically integrated into the medical curriculum, HFPS allows students to experientially gain realistic, practical experience to prepare for future clinical demands
2. **Practice to learn from mistakes**	MS2-04: "I think it is a good way to just kind of practice clinical stuff where there's not going to be a huge consequence if you don't do great, but you still learn a lot."			
3. **Feedback**	MS2-05: "I really enjoyed them all and I liked that we got feedback right away."			
4. **Safe space**	MS2-04: "It's a safe environment to fail and you're not being penalized for it so you actually are able to learn from those failures."			
5. **Preparation for improved patient safety**	MS2-04: "I think had we not had that experience it would be more of a shock going into third year and really not knowing like, even just to look at vital signs on a monitor."			
6. **Com-munication**	MS2-06: "…working with your team…and communicating, using each other's names and having a	Clear, concise communication allows for efficient healthcare		

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		teams		
7. IPE (teamwork/ roles)	MS2-09: "…I thought it was also good to simulate, in the sense of what it would be like in real-life working with other people, having to work on patients as a team."			
8. Experiential / immersive	MS2-10: "The whole room does kind of look a lot like an actual hospital room…I really think that kind of helps to get you in the right mindset and atmosphere."	Realistic environment to suspend disbelief and allow students to physically solve patient problems	HFPS should be integrated into the basic science curriculum and incorporate authentic high-fidelity scenarios	
9. Psychomotor skills	MS2-07: "I feel like I remember stuff better when I physically am using my hands and doing things and checking physicals."			
10. Enhanced fidelity	MS2-10: "I was interviewing the patient [manikin] and then saw sweat perspiring out of their forehead and everything, it was kind of cool the things that you are able to pick up on."			
11. Stress and performance anxiety	MS2-11: "I think the crunch for time can be kind of frustrating."			

Role of the Simulation Coordinator (emergent code)	MS2-08: "[The Simulation Coordinator] and [the physician-faculty member] do a really good job. I think they're part of the reason the program is so good and that I liked it so much and if it would have been less well-run, it could be something that was not as helpful."			
Preference for simulators over Standardized Patients (SPs) (emergent code)	MS2-05: "I almost found it easier to kind of be compassionate and be more interactive in the simulation versus like, a Standardized Patient who I know is like faking, you know?"			
12. Integration	MS2-03: "I like the idea of taking the concepts we're learning in class and actually being able to practice it and do something practical with it, and it was very pragmatic."	Context of simulation within the medical curriculum		
13. Period of acclimation to the simulated environment	MS2-05: "I think kind of the first couple times, you do have sort of brain lock and you, its harder to kind of think through things in a calm way and I, definitely by the end, I felt that I much improved there."			

Predictability and technology limitations (emergent code)	MS2-04: "I do think there were sometimes where the symptoms wouldn't match up with the normal presentations that we learn [due to equipment malfunction or delay]."			
Impact of education research (emergent code)	MS2-08: "I felt there was more box-checking going on from an administrative stand-point…just kind of seemed like an excuse to have them do research on our nursing student teams and us or something."			

Condensing Codes into Subcategories

Based on the coding rules (Table 4.1) and passages of interview text assigned into those codes, five codes (specifically, 'Think clinically,' 'Practice to learn from mistakes,' 'Feedback,' 'Safe space,' and 'Preparation for improved patient safety') were grouped and analyzed together to create a single subcategory, named '**Importance of safely gaining experience and developing a structured routine for future practice**' (Table 4.2). The ability to "think clinically" was coded as students explained HFPS allowed them to learn how to think in a high intensity situation, essentially "thinking on their feet" (MS2-02; MS2-05; MS2-10). This code was coupled with the fact that these students were gaining this experience and learning from their mistakes in a psychologically safe environment, free from actually harming a live patient (Code 5: Preparation for improved patient safety), while still obtaining valuable feedback from supervising physician-faculty members.

Together, the codes 'Communication' and 'IPE (teamwork/roles)' were condensed into a single subcategory, which was named '**Clear, concise communication allows for efficient healthcare teams**.' The majority of the coded transcript text associated with Code 6: Communication related to how the medical students obtained the ability to practice verbal, nonverbal, and teamwork communication skills with other healthcare professionals, specifically the nursing students at IUSON-B, in the simulated environment.

Another subcategory arose from the codes related to the fidelity and the immersive environment of the IUBIPSC, the ability to physically learn basic clinical skills, and the opportunity to practice managing psychological stress and performance

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anxiety while working in a healthcare setting. This subcategory was labeled '**Realistic environment to suspend disbelief and allow students to physically solve patient problems**,' and included the following four original codes and two emergent codes: 'Experiential/immersive,' 'Psychomotor skills,' 'Enhanced fidelity,' 'Stress and performance anxiety,' 'Role of the Simulation Coordinator' (emergent code), and 'Preference for simulators over Standardized Patients (SPs)' (emergent code). This subcategory reflects the realistic environment of high-fidelity simulation centers to aid in suspending disbelief, allowing students to physically solve patient problems and complete tasks.

A final subcategory was observed among two original codes and two emergent codes. The final subcategory was labeled '**Context of simulation within the medical curriculum**,' and incorporated the followed two original codes and two emergent codes: 'Integration,' 'Period of acclimation to the simulated environment,' 'Predictability and technology limitations' (emergent code), and 'Impact of education research' (emergent code). These codes were reasonably combined into a subcategory because they allude to the need for HFPS to be integrated into the existing medical curriculum in order for students to find the most benefit. The actual simulation scenarios are constructed from faculty and staff associated with the simulation center, and thus are amenable to augmentation if predictability issues arise, as they did in this study. Finally, although continued education research is required in order to discover the utility and benefits from this pedagogical intervention, this research must be skillfully conducted to avoid intruding on the learning space for students. Therefore, methodically and seamlessly

incorporating education research within the simulation schedule must also be considered within the context of the overall medical curriculum.

Condensing Subcategories into Main Categories

The four subcategories were further analyzed and condensed into two main categories based on the characteristics of the transcript quotes, thematic relationships, and overall contexts. The two subcategories concerned with the importance of safely acquiring patient care experience and practicing communication as a healthcare team during HFPS training embodies the preparation, clinical thinking, and teamwork mentality needed by physicians. Therefore, the first main category synthesizes these concepts and was named, '**HFPS safely prepares students to think and behave like physicians to contribute to an efficient healthcare team**.' This main category adequately summarizes the benefits of HFPS discovered in this study to provide a safe environment to practice, to learn from one's mistakes, work and communicate in a healthcare team, while obtaining essential recalibrating feedback, all with the expectation of preparing these students for improved patient safety in the future.

The second main category surfaced while analyzing the last two subcategories relating to the authenticity of the simulated experience and the implementation of this instructional intervention within the curriculum. The two subcategories 'Realistic environment to suspend disbelief and allow students to physically solve patient problems' and 'Context of simulation within the medical curriculum' together conveyed the significance of training students in highly realistic physical spaces and integrating these experiences within the foundation of the basic science medical curriculum; thus, these

two subcategories were encapsulated into the second main category entitled, '**HFPS should be integrated into the basic science curriculum and incorporate authentic high-fidelity scenarios**.'

Condensing Main Categories into the Theme

Collectively, the two main categories were finally condensed into one final theme for this pilot study. The first main category, 'HFPS safely prepares students to think and behave like physicians to contribute to an efficient healthcare team,' explained that HFPS safely imparts students with both the physical experience and mental preparation needed by successful physicians. Students are also able to operate as an efficient and effective healthcare team for improved patient safety in the future, aligning with the Hippocratic Oath required of all medical physicians. The second main category was labeled 'HFPS should be integrated into the basic science curriculum and incorporate authentic high-fidelity scenarios.' This second main category related to the actual implementation of the HFPS experience in medical education, rather than the benefits conveyed to learners, as was seen in the first main category.

These two main categories generated the final theme of this analysis, '**When strategically integrated into the medical curriculum, HFPS allows students to experientially gain realistic, practical experience to prepare for future clinical demands**.' Rooted in the interviews with second-year medical students, this theme captures the intent of HFPS to assist learners in transforming theoretical knowledge into actual practice. This theme highlights the experiential nature of physically interacting with a genuine simulated environment, the ability for HFPS to mimic realistic healthcare

dynamics, and the need for this instructional intervention to be thoughtfully incorporated into existing education curricula to obtain the most benefits.

Discussion

The intent of the second-year IUSM-B medical student interviews was to gain a broad understanding of the undergraduate medical education simulation experience in order to identify areas that may inform future in-depth research and answer the six research questions. The directed approach to QCA was the methodology used to analyze the interview transcripts. The initial QCA codebook was derived from the literature review (see Chapter 2), and consisted of 13 codes. Instances of all of these pre-determined codes were noted during the interview process. Four additional codes, known as emergent codes, were also identified directly from the interview transcripts of medical student simulation perceptions during the analysis that were not identified during the initial literature review. Specifically, the four emergent codes that were subsequently added to the codebook and incorporated into the final analysis included: 'Role of the Simulation Coordinator,' 'Preference for simulators over Standardized Patients (SPs),' 'Predictability and technology limitations,' and the 'Impact of education research.'

Four subcategories, two main categories, and one overall theme emerged from the original thirteen codes and four emergent codes. Recall that a subcategory can aid in the development of main categories, and main categories are considered the common patterns or domains that are rooted within the coded data (Bengtsson, 2016). Main categories are then combined to elucidate a theme (or multiple themes), which is a higher-level of

categorization that captures the underlying meaning of the entire data set (Graneheim & Lundman, 2004).

This discussion begins with an evaluation of the six research questions that guided this pilot study, incorporating a discussion of the relevant codes that aided in answering the respective research questions. Then the subcategories and main categories discovered during this analysis are examined. This chapter concludes with a discussion of the theme that arose from condensation of the main categories as well an acknowledgement of the inherent limitations associated with this pilot study.

Discussion of the Research Questions and Codes

Research Question 1 asked, "What do IUSM-B second-year medical students view as the most beneficial aspects about participating in HFPS?" All of the predetermined codes as well as two of the four emergent codes were associated with some type of beneficial aspect of the simulations. For instance, direct quotes regarding the following beneficial aspects of participating in HFPS included: the ability to think and feel like a physician (MS2-08; MS2-09); learning from mistakes in a safe environment (MS2-04); obtaining valuable feedback during the debrief session immediately following the simulations (MS2-05; MS2-07); working with nursing students as a healthcare team during IPE simulations (MS2-03, MS2-04, MS2-05, MS2-06); the immersive, hands-on simulation environment (MS2-07, MS2-10) which allowed them to practice psychomotor skills (MS2-04, MS2-10); and the ability for HFPS to integrate classroom knowledge with practical clinical experience (MS2-03, MS2-04, MS2-08).

It is interesting to note that while this research question queried into the beneficial aspects of HFPS, several disadvantages were noted in the interviews. The only codes that did not reflect a benefit of participating in simulations included two of the emergent codes; specifically, the 'Impact of Education Research' and 'Predictability and Technology Limitations.' This finding seems logical as these two particular codes represent negative aspects of HFPS participation; specifically, the feeling of intrusion by education researchers into the simulation space to obtain data, and feelings of predictable scenarios and technology limitations or malfunctions would not lend to beneficial feeling toward HFPS.

Although regarded as a negative aspect of participating in HFPS to some medical students, Code 11: Stress and performance anxiety was included as a beneficial aspect to answer Research Question 1 by other interviewees. Some medical students thought the stress added another component of realism to the HFPS experience and believed that they were adequately preparing for stressful situations that they will encounter during the future demands of their medical practice. This finding is consistent with HFPS literature, citing the realism of the HFPS environment coupled with the fast-paced patient scenarios prepare learners for real stressful clinical encounters (Gormley, Sterling, Menary, & McKeown, 2012; Span, 2015).

In addition to this dissertation research, various other education research projects are being conducted within the IUBIPSC, including interprofessional education (IPE) research between IUSM-B medical students and Bloomington nursing students (Feather et al., 2016), as well as investigations into communication skills observed during HFPS training within the IUBIPSC (Reising et al., 2011; Reising, Carr, Tieman, Feather, &

Ozdogan, 2015). In addition to any specific requests made by these researchers (e.g.,

surveys, interviews, focus groups), each student is expected to scan a Quick Response

(QR) code with their smartphones to complete an anonymous six question online survey

after every simulation intended for the Simulation Coordinator's knowledge for

improving future simulations. The six questions elicit qualitative feedback in the form of

Likert scale items regarding the students' perceptions of the simulation. The education

research aspects of investigating the efficacy and utility of HFPS, although necessary for

continued understanding of the impact of HFPS, was noticed by some students and added

to the requirements asked of students participating in the simulations within the

IUBIPSC.

The negative experiences of education research intrusion within the IUBIPSC

experienced by some medical students likely stemmed from a concept known as survey

fatigue. In a quantitative study exploring the consequences of repeated surveying of the

same population, Porter, Whitcomb, and Weitzer (2004) discovered a statistically

significant decline in response rates when multiple surveys were administered, a concept

known as a **survey fatigue** (defined as the time and effort required to participate in a

survey with overexposure to the survey process leading to diminished response rates).

However, their results indicated that the biggest impact was timing and distribution of the

surveys, with back-to-back surveys being most detrimental to response rates. They

concluded that a survey conducted in a previous semester may not affect response rates,

or the impact will be minimal. Therefore, spreading out survey distribution within the

IUBIPSC is critical for improvement in survey responses. Additionally, education

researchers should collaborate to combine questions onto a single survey or share IRB

approved data in order to minimize the number of surveys given to students during HFPS. This strategy should minimize their impact on affecting the simulation experience while still allowing for the collection of valuable data for continued research investigations.

Some medical students explained during the interviews that, at times, the simulations had a predictable quality to them. A stated benefit of HFPS is that simulator validity allows for repeated, standardized experiences to accommodate all students (Issenberg et al., 2005). Additionally, HFPS events have a typical sequence of a pre-brief orientation, followed by the simulation, and ending with a debrief session. Given this static structure, authors have noted that the lack of variability and predictability may lead to obvious scenarios in which students simply anticipate an event to happen (Landeen et al., 2015). In accordance with the literature, some students in this study explained that they began to expect the staged, typical narrative presented during the simulations.

The interviewees explained that technical inaccuracies displayed by the manikin were weaknesses of the HFPS experience as well. Although rapid technological advancements in the manufacturing and affordability of high-fidelity patient manikins (Badash, Burtt, Solorzano, & Carey, 2016) will likely negate many of these specific criticisms, the predictable scenario sequence within the IUBIPSC is something that can be readily augmented. This predictable sequence is likely beneficial for students to acclimate to the simulated environment and refine their clinical routines (Baxter et al., 2009); however, HFPS operators and faculty at IUSM-B can modify the existing structure by presenting unique patient cases, providing limited patient data during the pre-brief so students can obtain that information in the form of a physician referral letter

or transcript of an ambulance dispatch call center instead of always relying on the medical student interviewing the patient (Alinier, 2011), using HFPS for other areas besides the biological aspect of patient care, such as introducing students to diversity and cultural competence (Roberts, Warda, Garbutt, & Curry, 2014), or simply causing the manikin to code less frequently than was observed in this pilot study.

The inaccurate patient manikin presentations from possible equipment malfunction or software delays generated from the technology may be avoided with the use of Standardized Patients (SPs). As previously described, SPs are trained actors with knowledge of the signs and symptoms of a disease and are used in training and assessment, such as in the Objective Structured Clinical Examination (OSCE), described in greater detail in Chapter 5. However, SPs are not without their own inherent limitations; for example, the reliability of SPs to consistently provide a standardized experience has been called into question (Dotger et al., 2010), and invasive or sensitive procedures are impossible or unethical to replicate with SPs (Collins & Harden, 1998). In fact, some participants in this study indicated that they preferred working with the patient manikin to SPs, as captured in one of the emergent codes 'Preference for simulators over Standardized Patients (SP).' The medical students in this study who preferred the HFPS found the fake acting and inability for SPs to accurately present with specific signs and symptoms of a disease to be less beneficial than the patient manikin.

Although 'Predictability and Technology Limitations' and the 'Impact of Education Research' were noted as negative aspects to participating in simulations at the IUBIPSC for some medical students, the QCA procedure revealed the positive aspects of participating in HFPS outweighed these negative ones. While some students felt the

scenarios were contrived and the patient manikin unrealistic, most found the manikin and the immersive environment beneficial to their learning, further explaining Research Question 2, which asked, "How do these second-year medical students perceive the realism (fidelity) achieved within the IUBIPSC?" The concept of fidelity is central in simulation literature and has been described as the extent to which a spectrum of authentic elements reliably imitates reality (Fritz et al., 2008; Mowbray et al., 2003).

Opinions on the fidelity, or realism of the simulated environment, were mainly captured in Code 8: Experiential/immersive and Code 10: Enhanced fidelity. The real equipment, medical supplies, and high-fidelity manikins recreated what students will encounter during their clinical rotations and provided an immersive experience for them to learn and practice. For instance, medical students were observed in the IUBIPSC practicing psychomotor skills (Code 9) such as injecting medications into intravenous (IV) lines, performing chest compressions on the manikins, and slowly walking around the hospital room while thinking through diagnostic results that they ordered for their patient. Several medical students explained that this immersive, realistic environment was important to suspend their disbelief.

This physical manipulation of the environment conforms to the concepts elucidated in Experiential Learning Theory (ELT), which posits that knowledge is constructed through authentic experience followed by a reflection period (Kolb, 1984; Yardley et al., 2012). Several studies have confirmed the beneficial impact of participating in HFPS for supporting the acquisition of knowledge through authentic experience and reflection in medical and nursing students (McGaghie et al., 2009;

Morgan et al., 2016; Rourke, Schmidt, & Garga, 2010; Quraishi, Kimatian, Murray, Sinz, 2011).

When asked if they had ever found it difficult or experienced a barrier conversing with a plastic manikin during their simulation training, many medical students in this pilot study echoed similar feelings and the transcript data was assigned to Code 12: Integration or Code 13: Period of acclimation to the simulated environment based on the context of the text. Medical students in this study explained that there was a brief period at the beginning to adjust and become familiar with the technology, thereafter it was not difficult to imagine the manikin as a patient. Time was needed to acclimate to the simulated environment and effort was required to suspend disbelief, which is consistent with the literature (Dotger et al., 2010). Several interviewees in this study commented that participating in multiple simulations was an effective way to review basic science course topics with challenging clinical applications. When HFPS is logically weaved into the existing curriculum, simulation has the ability to "bridge the gap" between classwork and practical experience (Okuda et al., 2009; Sheakley et al., 2016; Weller, 2004), providing a medium for students to engage in a practical experiential activity.

In addition to the fidelity imparted by the realistic room and patient manikin, a key emergent code that was discovered in this analysis was the amount of fidelity conveyed from the Simulation Coordinator. The acting that the Simulation Coordinator displayed through the patient manikin's microphone and the authenticity she provided by expertly manipulating the patient manikin from the control room were acknowledged and appreciated by second-year medical students in this study. The Simulation Coordinator was also observed frequently instructing students, usually during the pre-brief orientation,

thus assuming the role of an educator in addition to the responsibilities of controlling the simulated environment. During the pre-brief, the Simulation Coordinator acknowledged that HFPS was not real; however, clearly reminded students to not let any limitations of HFPS affect their performance of what they would normally do in the future with a real patient. For example in some instances, rather than visually seeing something when performing a procedure or task, the Simulation Coordinator would verbally confirm that the procedure had been accomplished and would audibly indicate what the student found. These findings allude to the value and importance of the simulation operator; therefore, initial and continued training of simulation operators is essential to impart high-quality HFPS experiences for students (Dieckmann, Lippert, & Glavin, 2010; Gantt, 2012; McGaghie et al., 2010). A thorough review of the influence of a skilled simulation operator as well as currently available HFPS training can be found in Chapter 8.

First-year medical students at IUSM-B participate in one independent Basic Life Support (BLS) simulation in the spring semester (where they learn Cardiopulmonary Resuscitation (CPR) and perform chest compressions on the patient manikin), and one interprofessional education (IPE) simulation in the spring semester, in which medical and nursing students collaborate together to care for a patient with asthma. Simulations increase during the second year of medical school at IUSM-B, where medical students participate independently in two simulations after blocks of course material, and one IPE simulation each semester (fall and spring). Research Question 3 asked interviewees if they believed they had sufficient opportunities to participate in HFPS at IUSM-B, and the participants were divided; about half indicated that they would like more opportunities, but time constraints and pressure arising from state and national medical testing made

some feel that the number of simulations offered was sufficient. Balancing the need to adequately train future physicians in clinical skills and team communication with the demands from standardized testing is an ongoing debate (Ahmed, Abid, & Bhatti, 2017; Epstein, 2007).

While the need to successfully pass required examinations is imperative to progress through medical school, an argument may be made that developing the ability to think clinically is the goal of medical education, and was captured in Code 1: Think clinically. For example, second-year medical students in this study explained that their participation in HFPS helped them to think like a physician by building a patient care routine (Code 5), learning from their mistakes (Code 2), practicing to think confidently under pressure, and obtain valuable feedback (Code 3) within a psychologically safe environment (Code 4). Another example of the impact that HFPS had on these medical students is that it offered them a unique opportunity to begin working with other healthcare students as a cohesive team (Code 7).

The interprofessional education (IPE) simulations represented a major beneficial aspect of participating in HFPS within the IUBIPSC. These encounters provided the medical students with a chance to work with the nursing students as an interdisciplinary healthcare team during IPE simulations. In their first year of school, medical students are paired with one or two junior nursing students from IUSON-B. These IPE teams collaborate in at least four IPE simulations over the course of two years. When given the chance to work with the nursing students during IPE simulations, interviewees cited that this was one of the only opportunities they were able to practice communicating and working as a healthcare team before treating actual patients in real life. For instance,

during observations of IPE simulations, students learned a specific patient handoff sequence known as **SBAR**, which stands for Situation, Background, Assessment, and Recommendation. This first-letter mnemonic is an efficient memory device to communicate a thorough history and assessment to an incoming healthcare team member about a particular patient.

Medical students in this study found that working with the nursing students was beneficial for communication (Code 6) as well as learning their roles and responsibilities in the healthcare team (Code 7). HFPS provides a medium to develop essential communication skills and team training mentality while participating in IPE simulations (Dotger et al., 2010; Feather et al., 2016; Phitayakorn, Minehart, Pian-Smith, Hemingway, & Petrusa, 2015; Reising et al., 2011; Torres et al., 2014). This pilot study adds to the exiting body of research advocating for the use of HFPS to develop medical students, nursing students, as well as other allied healthcare students with the necessary skills to conduct themselves as an efficient and effective healthcare team.

In fact, when asked if the interviewees had any recommendations for how future simulations are conducted at IUSM-B (Research Question 5) and if they had any advice for future first-year medical students regarding their simulation experience (Research Question 6), many of the responses related to IPE. Several medical students in this study suggested that the IUSM-B faculty continue to implement IPE training with the nursing students and that future first-year medical students capitalize on this opportunity to collaborate with the nurses as a cohesive unit. Future directions for IPE research are detailed in Chapter 8.

Research Question 4, "Do the second-year medical students prepare prior to participating in HFPS in the IUBIPSC, and if so, what form does this preparation take?" was asked as little attention has been directed toward the amount and types of preparation that medical students engage with prior to participating in simulations in the literature. Henneman et al. (2007) provided an example from nursing education; before HFPS involving the assessment and management of a patient presenting with chest pain after a motor vehicle accident, nursing students were given instructional materials including: reading assignments, guidelines on participating in the simulation, standard simulation objectives, and the patient case summary. At IUSM-B, students receive an email with a brief introduction of what will be encountered during simulations and interviews conducted during this pilot study demonstrated a wide range of preparatory activities for the simulations. These preparatory activities included: reading and independent study, role-playing with peers, hypothesizing outcomes, and mentally constructing various scenarios. While most medical students interviewed were adamant about preparing for HFPS, one medical student admitted to actually not preparing for HFPS scenarios; this student claimed that the lack of preparation allowed them to keep an open mind as to possible differential diagnoses. This comment was an interesting and unexpected finding. The role that preparation has prior to a simulation is an area that should be investigated in future studies, as it may have an impact on what students actually get out of the simulation itself, and is explored more in Chapter 8.

Finally, not necessarily considered a 'positive' aspect of participating in simulations, Code 11: Stress and performance anxiety was acknowledged by some students in this study. It was true that some students claimed intense feelings of ignorance

in the simulation scenarios and performance anxiety knowing that they were being

watched and evaluated; however, a few students indicated that this stress and pressure

helped them to acclimate to the mindset required of the future demands of their practice.

This mentality is consistent with the literature on deliberate practice, in which sustained

training over time, immediate feedback to improve future performance, and ample

opportunities to perform repeatedly lead to the development of expertise (Ericsson,

2004). Deliberate practice requires consistent effort and is not innately enjoyable,

although motivation to continue stems from the fact that this type of practice ultimately

improves performance (Ericsson, Krampe, & Tesch-Römer, 1993). It is important to note

that experience alone will not yield expert performance; however, consistently engaging

in a highly structured, demanding practice coupled with active problem solving has been

cited to gradually build more complex and refined mental representations for rapid access

and skill execution, avoiding complacency and skill arrest (Ericsson, 2004).

Discussion of the Subcategories and Main Categories

The intent of QCA is to organize and condense large amounts of data into a

cohesive understanding (Mayring, 2000), and the directed approach to QCA was utilized

in this research to provide flexibility in the creation of emergent codes directly from the

data (Hsieh & Shannon, 2005). Although the creation of subcategories is not necessarily

required in QCA methodology, four subcategories were created in this analysis to assist

in the condensing process. Five codes were analyzed together based on the similar

interview text associated with those codes, and included: 'Think clinically,' 'Practice to

learn from mistakes,' 'Feedback,' 'Safe space,' and 'Preparation for improved patient

safety.' The subsequent subcategory, 'Importance of safely gaining experience and developing a structured routine for future practice,' described the medical students' ability to think clinically in a high-pressure, yet supportive, environment. Students then were able to learn from their mistakes through physical practice and instructor feedback. This experiential practice combined with the constructive criticism of a mentor is a hallmark of deliberate practice and the development of expertise, described previously.

Research in the ability for HFPS to develop essential communication skills has been described (Dotger et al., 2010; Feather et al., 2016; Phitayakorn et al., 2015; Reising et al., 2011; Torres et al., 2014), and the present study added to this knowledge. The next subcategory, 'Clear, concise communication allows for efficient healthcare teams,' condensed the codes 'Communication' and 'IPE (teamwork/roles).' The HFPS environment provided a medium for students from multiple healthcare professions to engage in complex, yet often assumed, communication skills required in a healthcare team. Codes related to the physical environment of the simulation center ('Experiential/immersive,' 'Psychomotor skills,' 'Enhanced fidelity,' 'Stress and performance anxiety,' 'Role of the Simulation Coordinator, and 'Preference for simulators over Standardized Patients (SPs)') led to the creation of another subcategory 'Realistic environment to suspend disbelief and allow students to physically solve patient problems.' Although debate continues regarding the importance of simulation fidelity, particularly given the substantial financial investment required (Harris, 2016), almost all interviewees claimed that the simulation center adequately conveyed realism and suspended their disbelief. Placing the medical students in an immersive environment

allowed them to practice clinical care of their patient manikin and manage psychological stress, anxiety, and pressure derived from the realistic scene.

The last subcategory, titled 'Context of simulation within the medical curriculum,' dealt with the placement and role of HFPS in the medical curriculum and condensed the codes 'Integration,' 'Period of acclimation to the simulated environment,' 'Predictability and technology limitations,' and 'Impact of education research.' Advocates for the integration of HFPS into existing curricula are numerous (Botma, 2014; Landeen et al., 2015; McGaghie et al., 2010; Sheakley et al., 2016), as a primary benefit of simulation appears to reside in its ability to help learners apply classroom knowledge to a practical situation.

The next step of the QCA procedure intends to further condense the subcategories into main categories, and two main categories were identified in this study. The first main category, entitled 'HFPS safely prepares students to think and behave like physicians to contribute to an efficient healthcare team,' combined the subcategory 'Importance of safely gaining experience and developing a structured routine for future practice,' and 'Clear, concise communication allows for efficient healthcare teams.' This main category encapsulated the need for students to safely acquire patient care skills and practice communicating and working together as a healthcare team. This early exposure to a structured clinical routine and team mentality has been shown to be efficacious. For example, in a randomized control study of a cardiopulmonary resuscitation (CPR) simulation using 237 fourth-year medical students, "technical instruction," which emphasized required physical skills, was compared to "leadership instruction," which emphasized closed-loop communication for improved team performance (Hunziker et al.,

2010). Those in the leadership instruction group demonstrated superior CPR performance than those in the technical instruction group four months after training, highlighting the importance of teamwork and communication in healthcare settings.

The second main category arose from condensing the last two subcategories dealing with the fidelity ('Realistic environment to suspend disbelief and allow students to physically solve patient problems') and the integration ('Context of simulation within the medical curriculum') of simulations within the existing curriculum. HFPS is a powerful tool that provides a medium for learners to acquire basic science (Harris et al., 2014) and clinical knowledge (Sheakley et al., 2016) through experiential learning. Experiential Learning Theory (ELT) explains that knowledge is constructed and meaning is created through authentic experience followed by a period for reflection on the activity (Kolb, 1984; Yardley et al., 2012). Studies examining the effectiveness of ELT have shown that experiential application of theoretical knowledge significantly improves successful attainment of learning outcomes (Abdulwahed & Nagy, 2009) and supports the development of expertise (DiLullo, 2015). This second main category captures the concepts of ELT in that the realistic, immersive HFPS environment integrated into the curriculum provides authentic learning experiences and aids medical students to transcend their knowledge from the classroom into the clinic. The HFPS sequence (of pre-brief, simulation, and debrief; see Figure 3.3) not only exposes students to an experiential, practical activity, but concludes their simulation experience with a personalized debrief allowing learners to reflect on their experience, ask pertinent questions, and assimilate new knowledge for improved future performance.

Discussion of the Theme of this Analysis

The main theme of this analysis was 'When strategically integrated into the medical curriculum, HFPS allows students to experientially gain realistic, practical experience to prepare for future clinical demands.' This concept is also reflected in the literature, as Baxter et al. (2009) stated, "students must have many opportunities to practice their clinical skills and to apply their theoretical knowledge in order to become a safe, competent practitioner" (p. 859). Although studies examining transfer-of-training of HFPS to real-world patient care are limited (Bond et al., 2007), and usually focus on short-term investigations of specific procedural tasks and skills (Fried et al., 2004; Grantcharov et al., 2004; Jones, Hunt, Carlson, Seamon, 1997; Owen, Follows, Reynolds, Burgess, & Plummer, 2002), second-year medical students in this study believed that their experiences would translate to an actual clinical setting. Many of the students noted that simply having the benefit of familiarity with various types of medical equipment common in patient rooms, such as a monitor displaying vital signs, was a direct benefit of the HFPS experience. These benefits imparted from use of a HFPS center have been cited in the literature (Feather et al., 2016; Issenberg et al., 1999; McGaghie et al., 2010; Scalese et al., 2007), and was directly obtained from second-year medical students themselves during this study. Although students can train with each other through patient cases in a classroom setting, such as seen in Team-based Learning (Burgess, McGregor, & Mellis, 2014; Michaelsen & Sweet, 2008) and Problem-based Learning (Galey, 1998), the added element of the realistic environment coupled with the ability to physically interact with equipment, the patient manikin, and other healthcare professionals is

important to replicate reality, thus theoretically decreasing cognitive load when working in real-world settings.

Limitations

Although a full discussion of the limitations inherent in this work is discussed in Chapter 8, a brief synopsis of the specific limitations related to this pilot study included the following: sampling technique, sample size, and methodology. First, the convenience sample obtained for this pilot study limits the external validity, or generalizability, of these findings. However, rich, qualitative descriptions were incorporated into the detailed interview and data analysis methodology described in this chapter, thus allowing researchers to apply the findings of this study to their particular simulation context and determine the extent of transferability (Merriam, 2009). Additionally, convenience sampling using only volunteers in this study may have induced a self-selection bias, in that only those medical students with strong opinions regarding HFPS may have participated. Although the class of 2018 consisted of 32 second-year medical students, only 11 participated in this study. While qualitative methodologies, including QCA, yield rich data even with small sample sizes, the transferability (related to the concept of 'external validity' in quantitative methodologies) limits the applicability of these findings to different populations of medical students. The medical students were incentivized with food to participate in the interview; however, other guaranteed incentives should be explored in an attempt to increase participation, which is discussed further in Chapter 8.

Finally, this pilot study focused solely on the perceptions among second-year medical students exposed to HFPS in their medical curriculum. Perception data has been

noted to be a less rigorous approach to educational inquiry, with recommendations in favor of objectively measuring learning outcomes by conducting experimental or quasi-experimental study designs (Bishop & Verleger, 2013; Karabulut-Ilgu, Cherrez, & Jahren, 2017). While quantitative data directly relating HFPS experience to actual clinical practice would be helpful, this was not feasible for this pilot study. However, quantitative analysis of the impact of HFPS using the Objective Structured Clinical Examination (OSCE) as a proxy variable for competent behavior was investigated and is presented in Chapter 5 of this dissertation. Given these limitations, it is still important to note that many of the conclusions drawn in this study were noted to be consistent with the literature.

Conclusions

Overall, medical student opinions overwhelmingly supported the utilization of HFPS in their existing medical curriculum; they noted several benefits of simulation, including clinical preparation, practice without harming real patients, and feedback from supervising faculty. Based on the results of this pilot study, the main theme that emerged was that when simulation is thoughtfully integrated into the basic science medical curriculum, it imparts valuable experience and prepares medical students for their future roles as competent physicians. Certain drawbacks about HFPS did surface during the interviews, such as predictable scenarios and questionable patient presentations from the equipment. However, simulations will continue to be utilized in healthcare education as Scalese et al. (2007) summarized, "spanning the continuum of educational levels and bridging multiple healthcare professions, medical simulations are increasingly finding a

place among our tools for teaching and assessment" (p. 48). Therefore, continued

research into the short-term and long-term effects of HFPS and the impact that it has on

student perceptions is critical to efficiently and effectively incorporate this instructional

strategy into modern medical curricula.

CHAPTER 5: QUANTITATIVE RESULTS AND ANALYSIS OF HIGH-FIDELITY

PATIENT SIMULATION TRAINING ON SELF-EFFICACY AND COMPETENCE

IN MEDICAL EDUCATION

Given that medical students must self-assess throughout their education and into their future medical careers (Sawdon & Finn, 2014), and contradictions, along with questions remain regarding the utility of HFPS, the following portion of this research study investigated the extent that HFPS training has on the competence and self-efficacy of medical students in years one through three of the medical curriculum at three campuses within Indiana University School of Medicine (IUSM). Three variables were used for the quantitative aspect of this research: self-efficacy, clinical competence (measured via a proxy variable as the Objective Structured Clinical Examination, or OSCE), and scores received by second-year medical students at Indiana University Bloomington (IUSM-B) during high-fidelity patient simulations (HFPS).

As defined in previous chapters, **self-efficacy** is a construct involving a complex interplay among several facets of personality and is an indicator of one's personal belief to successfully persist and accomplish a specific task, even under challenging circumstances (Bandura, 1977, 1986; Rodgers et al., 2014; Weiler & Saleem, 2017). Recall that self-efficacy is related to the term 'confidence,' but confidence is a nondescript term, referring to one's personal belief without indicating directionality or outcome expectations.

The term 'competence' permeates today's discourse in medical education, as many medical schools advertise "competency-based curricula" (Carraccio & Englander,

2000). For this research, **clinical competence** was defined as successful performance on the OSCE. OSCE scores were used as a proxy measure for competent behavior, which has been employed in previously published studies in medical, nursing, and dental education (Beckham, 2013; Brand & Schoonheim-Klein, 2009; Byrne & Smyth, 2008; Hsu, Chang, & Hsieh, 2015; Jolly et al., 1996; Mårtenseson & Löfmark, 2013; Mavis, 2001; McClimens, Ibbotson, Kenyon, McLean, Soltani, 2012; Nolan et al., 2017; Weiner et al., 2014). Sharma, Chandra, and Chaturvedi (2013) even defined 'OSCE' as an assessment method for evaluating competence of skills under a variety of simulated conditions.

This chapter presents the results from Research Questions 1 and 2 (Table 5.1; see Chapter 3 for a discussion of the research question hypotheses and rationales). Research Question 1 asked, "What is the relationship between ratings of clinical self-efficacy and clinical competence, as measured by scores on final performance-based assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?"

Research Question 2 was divided into two sub-questions; the first sub-question asked, "To what extent do simulation performance scores predict ratings of clinical self-efficacy among second-year medical students exposed to HFPS?" The second part of Research Question 2 asked, "To what extent do simulation performance scores predict clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?"

Table 5.1: Quantitative methods for Research Questions 1 and 2

Research Question	Populations	Method	Data Collection Instruments	Chapter
1. What is the relationship between ratings of clinical self-efficacy and clinical competence as measured by scores on final performance-based assessments (OSCE) among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?	IUSM-B: MS1, MS2, MS3 IUSM-E: MS2 IUSM-FW: MS1, MS2, MS3	Independent samples *t*-tests; Pearson correlations; ANCOVA	Questionnaire (Appendix A and Appendix B) and final OSCE scores	5
2. To what extent do simulation performance scores predict ratings of clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?				
2a. To what extent do simulation performance scores predict ratings of clinical self-efficacy among second-year medical students exposed to HFPS?	IUSM-B: MS2	OLS regression	OLS regression using simulation performance (scores from supervising instructor) to predict self-efficacy (questionnaire, Appendix A)	5
2b. To what extent do simulation performance scores predict clinical competence, as measured by scores on the final OSCE,			OLS regression using simulation performance (scores from supervising instructor) to	5

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among second-year medical students exposed to HFPS?			predict clinical competence (final OSCE score)	

ANCOVA, analysis of covariance; HFPS, high-fidelity patient simulation; IUSM-B, Indiana University School of Medicine-Bloomington (intervention group); IUSM-E, Indiana University School of Medicine-Evansville (control group); IUSM-FW, Indiana University School of Medicine-Fort Wayne (control group); MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students; OLS, ordinary least squares; OSCE, Objective Structured Clinical Examination; QCA, Qualitative Content Analysis.

Methodology

This portion of the dissertation research was designed to statistically measure the extent of perceived ability to successfully perform clinical tasks (known as self-efficacy), among first-year, second-year, and third-year medical students exposed to HFPS compared to those medical students not exposed to this instructional intervention. Three medical school classes (classes of 2018, 2019, and 2020) from three different IUSM campuses (IUSM-Bloomington, IUSM-Evansville, IUSM-Fort Wayne) were selected for inclusion in this study.

Each of the following methodology sections has been presented in Chapter 3 and will be briefly reviewed here. First, the recruitment will be discussed, followed by an examination of the Objective Structured Clinical Examination (OSCE) for each medical class cohort (i.e., first-year, second-year, and third-year medical students). Next, the questionnaire that was developed to quantify self-efficacy will be discussed; and then this section ends with an explanation of the statistical procedures utilized. This chapter concludes with the results and discussion of the quantitative data.

Recruitment Procedure

A convenience sample of first-year, second-year, and third-year medical students were selected on the basis of exposure to HFPS or no exposure to this instructional adjunct and were invited to participate in the study. Medical students that were included in the **intervention group** (IUSM-B) had at least one year of experience participating in HFPS within the Indiana University Bloomington Inter-Professional Simulation Center (IUBIPSC). In contrast, medical students included in the **control group** (students from the IUSM-E and IUSM-FW campuses) had very little to no experience with HFPS. All students within each cohort were invited to participate in this study at a single point during the academic school year, specifically between March and May 2017, depending on the specific date of each OSCE (see Table 3.3 for specific dates). A campus representative distributed email invitations, which consisted of a recruitment script approved by Indiana University IRB (protocol #1610985662) and an attached study information sheet (Appendix C).

The campus representatives were asked to email the medical students approximately one week apart, with first an initial email and then a follow-up email. The campus representatives included: the Medical Sciences Student Services Representative (IUSM-B); the Assistant Professor of Anatomy and Cell Biology (IUSM-E); and the Administrative Support Coordinator (IUSM-FW). Students were not mandated to participant in the study, but they were incentivized with the ability to enter a random drawing for a $100 Amazon.com Gift Card.

Class cohort population sizes as well as study participants are presented in Table 5.2. Note that the population sizes among the campuses selected for inclusion in this

study were relatively comparable, which was not the case for all IUSM centers, and was explained in detail in Chapter 3.

Table 5.2: Indiana University School of Medicine (IUSM) population and sample sizes

Medical Class	Class Year	Population Size (N)	Number Completed Questionnaire (n) (% response rate)	Number used for Analysis*
Intervention Group (simulation center): IUSM-B				
MS1	2020	36	18 (50.0)	17
MS2	2019	36	14 (38.9)	12
MS3	2018	8	6 (75.0)	5
Control Group (no simulation center): IUSM-E				
MS1	2020	24	0 (0)	0
MS2	2019	23	7 (30.4)	7
Control Group (no simulation center): IUSM-FW				
MS1	2020	32	12 (37.5)	12
MS2	2019	29	9 (31.0)	9
MS3	2018	12	4 (33.3)	4

* Review of the data showed patterns that appeared straight-lined (in which only one column or row of answers is selected), and were excluded from further data analysis; the rationale underlying this exclusion is discussed later in this chapter. IUSM-B, Indiana University School of Medicine-Bloomington; IUSM-E, Indiana University School of Medicine-Evansville; IUSM-FW, Indiana University School of Medicine-Fort Wayne; MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students.

Objective Structured Clinical Examination (OSCE)

The proxy measure for clinical competence for this research was scores on the **Objective Structured Clinical Examination (OSCE)**. The OSCE is a performance-based, experiential assessment of ability, which is similar to the experiential environment of a simulation center. The IUSM OSCE primarily uses Standardized Patients (SPs) and written diagnostic examinations in a simulated hospital room. However, OSCEs at other medical schools are continually incorporating HFPS elements into the assessment

(Harvey, Gillan, & Edgar, 2013); therefore, investigating the effect of HFPS training on OSCE performance is important. If required by the medical school, the medical school creates the OSCE; there is no universal OSCE. Therefore, IUSM creates the OSCE taken by all IUSM medical students, and each medical student cohort (i.e., first-year, second-year, and third-year) is given a specific OSCE to accommodate their current level of clinical knowledge and skills.

The first-year IUSM medical student OSCE is known as the "Foundations of Clinical Practice Year One Summative OSCE (FCP Y1 OSCE)," and will be described first; this is followed by a description of the IUSM second-year medical student OSCE, known as the "Introduction to Clinical Medicine Final OSCE (ICM2 Final OSCE)." Finally, the IUSM "End-Of-Third Year OSCE (EO3Y OSCE)" for third-year medical students will be discussed. Recall from Chapter 3 that low performing students are identified during the midterm OSCE and receive additional assistance and remediation prior to their final OSCE.

IUSM Foundations of Clinical Practice Year One Summative OSCE (FCP Y1 OSCE)

All first-year medical students within IUSM must pass the Foundations of Clinical Practice Year One Summative OSCE (FCP Y1 OSCE). This performance-based assessment accounts for 20% of the students' final FCP course grade, and is comprised of four sections (Table 5.3):

Section I Communication and Interpersonal Skills (30% of overall grade);

Section II Data Gathering – History and Physical Exam (30% of overall grade);

Section III Documentation (30% of overall grade); and

Section IV Professionalism (10% of overall grade).

The total score for each OSCE section is converted into a percentage, then that percentage is multiplied by the weight for that section. The **composite OSCE score** is the sum of all weighted section percentages. Numerical scores from each OSCE section, the composite OSCE score, and written feedback from SPs and/or an assigned faculty grader comprise the complete OSCE assessment.

Table 5.3: Abbreviated Foundations of Clinical Practice Year One Summative OSCE (FCP Y1 OSCE) Score Rubric

Section	Weight of Overall Grade (%)	Points Possible	Passing Cutoff (%)*
Section I Communication and Interpersonal Skills	30	4	50
Section II Data Gathering – History and Physical Exam	30	23	65
Section III Documentation	30	42.5	52.5
Section IV Professionalism	10	5	–
Composite Score	N/A	74.5	N/A

* First-year IUSM medical students must achieve passing cutoff scores for sections I, II, and III only; there is no passing cutoff for the FCP Y1 OSCE composite score. Note the presented rubric is an abbreviated version of the original rubric to maintain confidentiality of the exam.

'Section I Communication and Interpersonal Skills' (30% of the overall grade) consists of a total of four possible points based on student responses and is completed by an SP using a checklist. The SP assesses students on the use of open-ended questions and transitions that encourage the patient to tell their story, as well as use of non-verbal skills, and the ability to demonstrate empathy for the patient.

'Section II Data Gathering – History and Physical Exam' (30% of the overall grade) consists of two parts, 'Data Gathering – History Taking' items (addressing the

ability to collect information during the patient interview relevant to obtaining a list of differential diagnoses) and 'Data Gathering – Physical Exam' items (addressing physical aspects of the encounter such as washing and/or sanitizing their hands, appropriately draping the patient, and completing the required physical exam items). The SP scores these skills from a checklist based on their encounter with the medical student.

'Section III Documentation' (30% of overall grade) is based on the written history and physical exam documentation from a standardized rubric graded by a group instructor or site/course director within the state of Indiana. Written comments from this faculty grader are also provided to the students on their report.

Finally, 'Section IV Professionalism' (10% of overall grade) is evaluated based on timeliness of arrival to the OSCE, professional attire, possession of a professional identification badge and stethoscope, and being respectful to the faculty and staff facilitating the OSCE. A passing grade for the FCP Y1 OSCE is 50% or higher on 'Section I Communication and Interpersonal Skills,' 65% or higher on 'Section II Data Gathering – History and Physical Exam,' and 52.5% or higher on 'Section III Documentation.' There is no passing cutoff for the FCP Y1 OSCE composite score.

IUSM Introduction to Clinical Medicine Final OSCE (ICM2 Final OSCE)

All second-year medical students within IUSM complete the Introduction to Clinical Medicine Final OSCE (ICM2 Final OSCE). The ICM2 Final OSCE evaluates student performance based on four domains: 'Physical Exam Skills,' 'Full History and Physical Documentation and Diagnostic Skills,' 'Communication Skills,' and 'Focused Case Documentation and Diagnostic Skills' (Table 5.4).

Table 5.4: Abbreviated Introduction to Clinical Medicine Final OSCE (ICM2 Final
 OSCE) Score Rubric

Section	Weight of Overall Grade (%)	Points Possible	Passing Cutoff (%)*
Physical Exam Skills	35	22	–
Full History and Physical Documentation and Diagnostic Skills	35	55	–
Communication Skills	5	24	–
Focused Case Documentation and Diagnostic Skills	25	60	–
Composite Score	N/A	161	70%

* Second-year IUSM medical students must achieve a passing cutoff score for the ICM2
 Final OSCE only. Note the presented rubric is an abbreviated version of the original
 rubric to maintain confidentiality of the exam.

The 'Physical Exam Skills' section is determined by the SP's assessment of the
required checklist items in the full history and physical exam station. This section
consists of 22 possible points and accounts for 35% of the overall OSCE grade. The 'Full
History and Physical Documentation and Diagnostic Skills' section is evaluated by
faculty according to items listed on a specific rubric. A total of 70 points is possible for
this section and it accounts for 35% of the overall grade. 'Communication Skills' is
determined from SP checklist responses in two focused case stations. Lastly, 'Focused
Case Documentation and Diagnostic Skills' is graded by faculty on written portions
based on a rubric encompassing items such as clinical data, differential diagnoses with
supporting data, and diagnostic work.

Comments from both SPs and faculty evaluators are provided to students on the
report, and the passing composite score for the entire exam is 70%.

IUSM End-Of-Third Year OSCE (EO3Y OSCE)

The End-Of-Third Year OSCE (EO3Y OSCE) is based on the objectives of the third-year clerkships, consists of ten stations, and is scored on two components (Table 5.5): the Integrated Clinical Encounter (ICE) and Communication and Interpersonal Skills (CIS). The ICE score is determined as a weighted percentage based on points received for documentation of post-encounter notes and points received for data-gathering items related to history-taking questions and physical exam findings across the ten stations. The CIS score is determined as a percentage based on the points received for performance on five components of the SP checklists across the ten stations.

Table 5.5: Abbreviated End-Of-Third Year OSCE (EO3Y OSCE) Score Rubric

Component	Passing Cutoff (%)
Integrated Clinical Encounter (ICE)	62.85
Communication and Interpersonal Skills (CIS)	69.22

* Third-year IUSM medical students must achieve a passing cutoff score for the EO3Y OSCE ICE and CIS components only; no numerical score data was provided to the author for the subset of categories within each component; to the authors' knowledge, there is no composite OSCE score for third-year IUSM medical students. Note the presented rubric is an abbreviated version of the original rubric to maintain confidentiality of the exam.

The ICE component of the EO3Y OSCE includes assessment of patient documentation of pertinent findings, data interpretation, generation of an appropriate differential diagnosis list, formulating a well-supported, safe, and efficient treatment plan, and conduct a physical examination. The CIS component assesses a student's ability to establish a chronology of the primary problem, provide an explanation of what is likely occurring to the patient and check for patient understanding, seek clarification or

elaboration of the patient's feelings, and encourage and answer questions using clear and understandable statements while listening attentively and showing interest, care, concern, and respect for the patient.

IUSM Medical Student Self-Efficacy and Simulation Perception Questionnaire

To investigate the research questions previously listed concerning IUSM medical student self-efficacy, a questionnaire was developed to assess perceived level of self-efficacy on a number of tasks and skills required of a physician. This questionnaire was given to consenting first-year, second-year, and third-year medical students in both the intervention group (IUSM-B) and the control group (IUSM-E and IUSM-FW). A description of the "Medical Student Self-Efficacy and Simulation Perception Questionnaire" (Appendix A and Appendix B) and the theoretical foundations guiding the construction of the questionnaire have been previously discussed in Chapter 3. Briefly, this questionnaire was modeled after the reliable and validated survey based on a survey by Woolliscroft and colleagues (1993) in their investigation of third-year medical students' clinical self-assessment compared to external measures of performance. The questionnaire in the present study consisted of three sections: an evaluation of self-efficacy; simulation perception and OSCE preparation; and general demographic data.

The first section of the questionnaire asked participants to rate themselves on a scale with 10-unit intervals from 0 (I cannot do at all), which indicated a low assessment of ability, to 100 (I'm highly certain I can do), which indicated a high assessment of ability. The 12 questionnaire items in this section were grouped into four divisions, or self-assessment areas, reflected in the section subheadings on the questionnaire (Table

5.6): 'Patient Interview and Medical History,' 'Physical and Diagnostic Examination,'

'Application of Knowledge,' and 'Interpersonal Skills and Communication.'

Table 5.6: Self-assessment areas (1-4) and individual items (a-d) from the Appraisal Inventory of the first section of the questionnaire

1. Patient Interview and Medical History
a. Interview a patient about their chief complaint in a hospital or clinical settings
b. Accurately document a patient's medical history
Average of Patient Interview and Medical History Section
2. Physical and Diagnostic Examination
a. Perform a physical examination in a hospital or clinical setting
b. Interpret findings from a physical examination
c. Order appropriate diagnostic tests
d. Interpret results from diagnostic tests
Average of Physical and Diagnostic Examination Section
3. Application of Knowledge
a. Integrate relevant basic science knowledge to the patient's presentation
b. Create a list of appropriate differential diagnoses
c. Generate a treatment plan
Average of Application of Knowledge Section
4. Interpersonal Skills and Communication
a. Clearly communicate with other members of the healthcare team about a patient case
b. Explain the reasoning of what is likely causing the primary complaint to a patient
c. Connect with patients and verify patient understanding
Average of Interpersonal Skills and Communication Section

The four self-efficacy areas represent various dimensions and were constructed to obtain nuanced data to differentiate each medical class cohort. For instance, first-year medical students were expected to only collect a history and physical exam, whereas second-year and third-year medical students were also expected to diagnose a patient and generate treatment plans. However, as employed by Woolliscroft et al. (1993), the four self-efficacy areas were consolidated into a single, averaged composite self-efficacy score for each subject to simplify modeling procedures.

The final question in the Appraisal Inventory section consisted of one overall assessment item based on the revised Dreyfus Model of Skill Acquisition (Carraccio et al., 2008). Recall from Chapter 3 that this model lists six ascending stages that learners pass through toward the acquisition of a skill. The six stages include: novice, advanced beginner, competent, proficient, expert, and master. Participants of the current study were asked to indicate their perceived level of overall ability as a physician at this time in their medical career on the revised Dreyfus Model of Skill Acquisition.

The second section of the questionnaire consisted of items related to perceptions of HFPS and OSCE preparation. This section was slightly different between the intervention and control groups. Both groups received a ranking question, which listed five educational strategies utilized in medical school to teach clinical skills, including: computer-based modules; Standardized Patients (real actors trained to play a patient); real patients, part-task trainers (for example, small groups learning around a part-task trainer such as Harvey® Cardiopulmonary Simulator), and high-fidelity patient simulations (realistic room and responsive manikin). Participants were asked to rank their preferred teaching strategies for learning clinical skills from one, the most helpful for learning clinical skills, to five, the least helpful for learning clinical skills. The next question presented to both groups asked participants about their perception of preparedness to successfully complete their upcoming OSCE. This nominal bipolar scale included: 'Completely unprepared,' 'moderately unprepared,' 'slightly unprepared,' 'slightly prepared,' 'moderately prepared,' and 'very well prepared.'

In addition to these questions, the intervention group also had a single-response question in this section, asking respondents to select the single most beneficial aspect

about participating in simulation at the IUBIPSC. The item had six options and a seventh

fill-in option. The six options were derived from the literature review (Chapter 2) and

pilot study (Chapter 4) and included: 'ability for repeated practice,' 'exposure to a wide

variety of patient cases,' 'debriefing with a faculty member after the simulation,'

'opportunities to integrate basic science knowledge with clinical practice,' 'working with

nursing students during interprofessional (IPE) simulations,' and 'I did not find

simulation beneficial.' Lastly, the intervention group had one open-response question in

this section that asked about overall impressions regarding their experience participating

in simulations at the IUBIPSC during their medical education. Results from this open-

response item are presented with the qualitative results in Chapter 6.

The third and final section of the questionnaire captured demographic data for

both the intervention and control groups, and included: academic rank, age, ethnicity, and

gender. As explained in Chapter 3, these variables were collected because age at

matriculation, race, and self-identified gender have all been shown to influence

overestimation and underestimation of ability and academic performance in medical

school (Hall et al., 2016; Minter et al., 2005; Sheakley et al., 2016).

Medical students who chose to participate in the study completed the

questionnaire electronically and were required to enter their Indiana University Central

Authentication Service (CAS) credentials to verify identification and provide their

electronic signature for the FERPA release. Participants were informed in the

questionnaire introduction that completion of the questionnaire signified acceptance of

the data pairing procedure of their responses to their OSCE scores necessary for this

research, with subsequent redaction of identifying information after pairing.

Methodology of Statistical Procedures

The following statistical tests were developed in collaboration with a statistical consultant. Since self-efficacy was measured as the average of several questionnaire items, these variables were considered continuous, and thus parametric tests were appropriate. As noted below and in the limitations section in Chapter 8, the sample size obtained for this study was low, thus assumptions were violated and the tests were underpowered. A small sample size and small effect size significantly increases the chance of a type II (i.e, false negative) error (Grice, Wenger, Brooks, & Berry, 2013). However, the statistical consultant advised continuing with the original statistical plan as it represented the most appropriate and available methods to answer the research questions and demonstrates theoretical understanding and practical application of the data for future iterations of this research when conditions are more receptive to statistical analysis (M. Frisby, personal communication, May 17, 2018). Therefore, interpretation and conclusions drawn from this portion of the research should be cautiously considered. Additionally, the *p*-value was not adjusted even though multiple statistical procedures were conducted on the sample data set. There is strong disagreement about the need for adjusting the *p*-value in exploratory inquiries such as the present research, and may only be needed for cases with definitive hypotheses and real world implications (M. Frisby, personal communication, April 9, 2018).

The data obtained from participant responses was exported from Qualtrics software (Qualtrics, LLC, Provo UT, March-August, 2017) to Microsoft® Excel® for Mac 2011 (Microsoft Corporation, Version 14.7.2) for organization, preliminary analysis, and for creating graphical representations of the data seen in this chapter. All statistical

analyses were performed using IBM SPSS Statistics for Mac OS X, Version 24.0 (IBM Corp., Armonk N.Y., USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations were computed to describe the sample. The Cronbach alpha reliability estimates were calculated for internal consistency of the four self-efficacy areas that were presented on the questionnaire to all medical students ($n = 66$), from first-year through third-year.

For Research Question 1, independent samples t-tests were calculated to compare composite OSCE scores and average self-efficacy ratings between the intervention group exposed to HFPS and the control cohorts who were not exposed to this educational intervention. Data was assessed for the assumptions associated with independent samples t-tests prior to conducting them, and included: normality of the distribution (analyzed by observing the skewness and kurtosis of the data distributions remain between -1 and $+1$, and the Shapiro-Wilk value should not be statistically significant); homoscedasticity (also known as homogeneity of variance, which requires similar variances of the residuals across all levels of the independent variables, and was assessed by observing a non-statistically significant value for Levene's Test of Equality of Error Variances); and box plots were assessed to check for the presence of outliers. Some of these assumptions were violated, which is likely due to the sample size as previously mentioned. An attempt to correct for departures from the assumptions through a logarithmic transformation was not successful. However, since the consulted statistician advised to continue with this plan, data analysis proceeded for theoretical purposes.

To measure the magnitude of the effect of average self-efficacy rating on composite OSCE score, effect sizes were calculated. Effect sizes for the independent

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samples *t*-tests were reported as Cohen's *d,* and considered to be a large effect at $d = 0.80$, a medium effect at $d = 0.50$, and a small effect at $d = 0.20$ (Cohen, 1992).

Pearson correlations between the average ratings of self-efficacy and composite OSCE scores were computed within each class level (e.g., first-year medical students, second-year medical students, third-year medical students) for both the intervention and control groups. Since self-efficacy was measured as the average of several questionnaire items, these variables were considered continuous, and thus Pearson correlation coefficient (*r*) was appropriate (M. Frisby, personal communication, April 9, 2018). Correlation coefficients are considered effect sizes (Field, 2013), and the strength of the correlations was interpreted based on recommendations by Mukaka (2012) for appropriate use in medical education research (Table 5.7).

Table 5.7: Correlation interpretations as recommended by Mukaka (2012)

Direction of Correlation	Size of Correlation	Correlation Strength
Positive – variables are directly related (i.e., as the value of one variable goes up, the value of the other variable goes up)	.90 – 1.00	Very high positive (very strong)
	.70 – .90	High positive (strong)
	.50 – .70	Moderate positive
	.30 – .50	Low positive (weak)
No correlation	.00 – .30	Negligible (very weak)
Negative – the variables are inversely related (i.e., as the value of one variable goes up, the other variable goes down)	-.30 – -.50	Low negative (weak)
	-.50 – -.70	Moderate negative
	-.70 – -.90	High negative (strong)
	-.90 – -1.00	Very high negative (very strong)

The final analysis conducted to investigate Research Question 1 was a one-way analysis of covariance (ANCOVA). This procedure was used to test the combined and

independent effects of average self-efficacy rating and group assignment (intervention

using HFPS and control not using HFPS) on OSCE performance, measured as composite

OSCE score, for each medical class cohort. The assumptions associated with ANCOVA

were assessed prior to interpretation, including: covariate values should be linearly

related to the dependent variable at each level of the independent variable; homogeneity

of regression, in which there is no interaction between the covariate and the independent

variable, and homoscedasticity of the standardized residuals. Effect sizes for the results of

the ANCOVA modeling were reported as partial eta squared (η^2) and considered to be a

large effect at $\eta^2 = .1379$, a medium effect at $\eta^2 = .0588$, and a small effect at $\eta^2 = .0099$

(Richardson, 2011). Again, these tests were performed based on recommendations from a

statistical consultant.

For Research Question 2, HFPS scores were used. As previously described in

Chapter 3, second-year medical students in the intervention group (IUSM-B) received

numeric grades from a supervising physician-faculty instructor after participating in

HFPS. The specific simulations these students experienced were also previously

described in Chapter 3. The scores from these simulations were averaged to create a

single composite simulation score for data analysis, and entered into an **ordinary least**

squares regression (OLS) regression model to determine the extent that participating in

HFPS had on composite OSCE scores (OLS Regression Model 1), and the extent that

participating in HFPS had on average self-efficacy ratings (OLS Regression Model 2).

The outcome variables (dependent variable) were OSCE score and average clinical self-

efficacy score, while the predictor variable (independent variable) was HFPS simulation

scores. The assumptions associated with OLS regression were assessed prior to

conducting the analysis (reported in the results section), and included: normality, linearity, homoscedasticity, and the presence of outliers. All statistical results were considered significant at $p \leq .05$. Regression employs a listwise selection (in the case of missing data, the subject will not be included in the model), so all data from subjects were verified as present before proceeding.

Additional calculations were performed on the questionnaire data that were not necessarily related to Research Questions 1 or 2. The last question in the first section of the questionnaire referred to the revised Dreyfus Model of Skill Acquisition (Carraccio et al., 2008; refer to Chapter 3 for more information regarding this model), and asked respondents to select their rating of their overall ability as a clinician at this time in their medical education. The frequency of ratings selected by the medical students within each class cohort were calculated and then presented as a distribution (Figure 5.6). This frequency distribution was then compared to the proposed Dreyfus ratings that medical students should have selected based on their current year in school that is found in the literature; for example, the realistic Dreyfus classifications expected of first-year medical students is 'Novice,' while junior-level medical students would be classified as 'Advanced beginner,' and residents would be considered 'Competent' (Batalden, Leach, Swing, Dreyfus, & Dreyfus, 2002).

The second section of the questionnaire consisted of items related to perceptions and demographic data. The perception items included a ranking question of instructional strategies used in medical school to teach clinical skills, including: high-fidelity patient simulations (HFPS), Standardized Patients (SPs), real patients, part-task trainers, and computer-based modules. Respondents were asked to rank order their preferred

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instructional strategy from 1, most helpful for learning clinical skills, to 5, least helpful for learning clinical skills.

Weighted averages were computed on the frequency distributions as described by Cendan and Johnson (2011) among each class cohort in the intervention and control groups to discern relative rankings of preferred instructional strategies to teach clinical skills in medical education. Weighted averages were calculating as follows: First, the frequency of each ranking (1 through 5) was calculated for each of the five instructional strategies. Next, the frequencies of each rank were multiplied by weights: first-place values were multiplied by a weight of 5; second-place values were multiplied by 4; third-place values were multiplied by 3; fourth-place values were multiplied by 2; and fifth-place values were multiplied by 1. Weighted values were then summed for each instructional strategy, and then divided by the total number of respondents in each group to yield a final ranked score for each instructional strategy.

The question related to preparedness for the OSCE was analyzed through a frequency distribution. Two additional questions presented on the intervention questionnaire asked participants to select the single most beneficial aspect about participating in HFPS, which was also analyzed through a frequency distribution, and the final item on the intervention questionnaire was an open-response question, the results of which are presented in Chapter 6.

Results

This section will be presented in four parts. First, the number of participants will be listed and their self-reported demographic data from the completed questionnaires will

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be described. Next, the results from Research Question 1 will be presented, followed by

the results from Research Question 2. The remainder of the questionnaire analysis will

then be presented, including the Dreyfus ratings, rankings of preferred teaching

interventions, preparedness for the OSCE, and the benefits of HFPS.

Demographic Data

Of the 71 total participants who completed the study, only 66 questionnaire

responses were retained for data analysis. After careful inspection of the questionnaire

responses, one first-year medical student, two second-year medical students, and one

third-year medical student, all from the intervention group, were suspected of straight

lining the self-efficacy inventory of the first part of the questionnaire. **Straight-lining** is a

survey methodology concept in which participants select only a single column or row of

items in a series of questions; thus, they do not provide an accurate representation of their

perception and subsequently skew the entire data set and data quality (Kim, Dykema,

Stevenson, Black, & Moberg, 2018). These respondents had marked "0 (I cannot do at

all)" for every item of the self-efficacy portion of the questionnaire. Given that this

questionnaire was distributed approximately one to two weeks prior to taking the IUSM

OSCE, a high-stakes performance-based assessment, it is unreasonable to assume that

these medical students had absolutely no sense of self-efficacy about any item in the four

self-assessment areas in this section. Additionally, one participant from the IUSM-FW

control group had indicated that they were a third-year medical student on the

questionnaire; however, during the interview it was discovered that they were actually in

their fourth and final year. Therefore, those four participants that had straight-lined

responses and the one fourth-year medical student response were removed from further data analysis.

Demographic data obtained from questionnaire responses is presented in Table 5.8. The self-identified demographic data collected in the third section of the questionnaire included: current year of medical school, age in years, ethnicity, and gender. Age, ethnicity, and gender were all constructed as open-response questions to permit freedom of choice for the respondents, given the spectrum of gender and ethnicity identifications.

Of the 66 completed questionnaires, 29 (43.9%) were from first-year medical students (MS1), 28 (42.4%) were from second-year medical students (MS2), and 9 (13.6%) were from third-year medical students (MS3). Age was relatively homogenized for each class cohort, ranging from 22 to 26 years old ($M = 23.5$, $SD = 1.022$) for MS1; 22 to 27 years old ($M = 24.1$, $SD = 1.008$) for MS2, and 23 to 31 years old ($M = 25.8$, $SD = 2.279$) for MS3. All participants self-identified their gender as being either male or female; 38 (57.6%) were female. The majority of all participants identified as 'Caucasian / White' (43, 65.1%), followed by Mixed (7, 10.6%), and 'Asian/Asian-American' (6, 9.1%).

Table 5.8: Participant demographics ($n = 66$)

Variables	Number of students who completed the questionnaire (%)					
Medical Level	**MS1**		**MS2**		**MS3**	
	Inter-vention	**Control**	**Inter-vention**	**Control**	**Inter-vention**	**Control**
Sample Size	17	12	12	16	5	4
Age (years)						
22-24	16 (94.1)	10 (83.3)	8 (66.7)	14 (87.5)	1 (20.0)	1
25-27	1 (5.9)	2 (16.7)	4 (33.3)	2 (12.5)	3 (66.7)	3
28-31	–		–		1 (10.0)	–
Gender						
Male	10 (58.8)	5 (41.7)	5 (41.7)	6 (37.5)	1 (20.0)	1 (25.0)
Female	7 (41.2)	7 (58.3)	7 (58.3)	10 (62.5)	4 (80.0)	3 (75.0)
Ethnicity						
Caucasian / White	13 (76.5)	5 (41.7)	7 (58.3)	13 (81.3)	2 (40.0)	3 (75.0)
African-American	–	1 (8.3)	1 (8.3)	–	–	
Asian / Asian	–	2 (16.7)	2 (16.7)	–	1 (20.0)	1 (25.0)
Indian / Pakistani	–		–	2 (12.5)	–	
Hispanic / Latino(a)	3 (17.6)	2 (16.7)	1 (8.3)	–	–	
Multiracial	–	2 (16.7)	1 (8.3)	1 (6.3)	1 (20.0)	–
Preferred not to answer	1 (5.9)	–	–		1 (20.0)	–

When determining the extent of an intervention on a dependent variable between different populations, as was done in this study, it is important to try to control for as many confounding variables as possible. Controlling for confounding variables is particularly challenging in education research. Aspects such differences in curriculum and instructional methods among IUSM campus centers, and the backgrounds and

personality characteristics of the medical students in the study, could all influence self-efficacy between the groups, and thus interfere with the ability to detect an effect of HFPS on OSCE scores.

While there were variations in the timing and length of the courses at the time of this study, all IUSM campuses covered the same course topics and were required to share an 80% core of content in each course (V. O'Loughlin, personal communication, May 22, 2018). Additionally, students can prefer campuses (Figure 3.1), but IUSM data indicates there are no major differences in student populations among the eight regional campuses; although, there may be slight differences between students at regional campuses compared to the Indianapolis (IUSM-IUPUI) campus (Brokaw et al., 2009). Since the present study used only three regional campuses, it likely included a representative sample of the IUSM student population (J. Brokaw, personal communication, May 22, 2018).

All first-year ($n = 12$) and third-year medical students ($n = 4$) from the control group came from IUSM-FW, so it was not possible to compare these students. However, to establish that second-year medical students from IUSM-E ($n = 6$) and IUSM-FW ($n = 9$) that served as the second-year medical students of the control group were academically similar, composite OSCE scores and average self-efficacy ratings were compared using independent samples t-tests. When considering the composite OSCE score data, Levene's test for equality of variances was violated, $F(1,14) = 16.615$, $p < .001$. Owing to this violated assumption, a t-statistic that does not assume homogeneity of variance was considered. The Levene's test for equality of variances was not violated for average self-efficacy rating, thus a t-statistic assuming equal variances was considered.

Means for composite OSCE scores were very similar between the second-year medical students from the two control campuses (IUSM-E: M = 84.76; SD = 6.03; IUSM-FW: M = 85.21; SD = 2.17), and were found to be non-significant ($t(14)$ = -.188, p = .856, d = .094, observed difference: -0.449, 95% CI [-6.07, 5.17]). In contrast, average self-efficacy ratings were higher for IUSM-E second-year medical students (IUSM-E: M = 664.29; SD = 88.67; IUSM-FW: M = 562.22; SD = 80.28), and were found to be statistically significant ($t(14)$ = 2.412, p = .030, d = 1.198, observed difference: 102.06, 95% CI [11.30, 192.83]). Therefore, although there was no statistically significant difference in the composite OSCE scores between the IUSM-E campus and the IUSM-FW campus (therefore establishing that the second-year medical students from the two control campuses were academically similar), the second-year medical students at the IUSM-E campus had statistically significant higher average self-efficacy ratings than those second-year medical students at the IUSM-FW campus. An explanation for this anomaly is presented in the Discussion section of this chapter.

Research Question 1 Results

The four self-efficacy areas included: 'Patient Interview and Medical History;' 'Physical and Diagnostic Examination;' 'Application of Knowledge;' and 'Interpersonal Skills and Communication.' The reliability statistic (Cronbach's alpha) was .779 for the two items within the 'Patient Interview and Medical History' area; .937 for the four items within the 'Physical and Diagnostic Examination' area; .939 for the three items within the 'Application of Knowledge' area; and .825 for the three items within the 'Interpersonal Skills and Communication' area. Based on the recommendations by George and Mallery

(2003) of Cronbach's alpha > .9 (Excellent), > .8 (Good), > .7 (Acceptable), the first

section of the questionnaire had excellent to acceptable reliability irrespective of the

medical class cohort.

To answer Research Question 1, means and standard deviations of composite

OSCE scores were calculated for each class cohort and independent-samples *t*-tests were

conducted to compare composite OSCE scores between the intervention (IUSM-B) group

and the control group (Figure 5.1). Note that the assumption of normality was violated

and logarithmic transformation of the data did not resolve this violation.

Composite OSCE scores were high for both groups of first-year medical students;

the composite OSCE score for the MS1 intervention group was 93.49 ($SD = 4.24$) and the

composite OSCE score for the MS1 control group was 91.81 ($SD = 3.91$). The MS1

intervention group had slightly higher composite OSCE scores; however, this difference

was not statistically significant ($t(27) = 1.090$, $p = .285$, $d = 0.41$, observed difference:

1.68, 95% CI [-1.49, 4.87]). Note that the assumption of normality was violated for the

first-year OSCE comparison (intervention: skewness = -1.509; kurtosis = 3.960; control:

kurtosis = -1.036) and there was one outlier.

Figure 5.1: Composite OSCE scores, as a percentage, for the intervention group (IUSM-B) compared to the control group (IUSM-E and IUSM-FW)
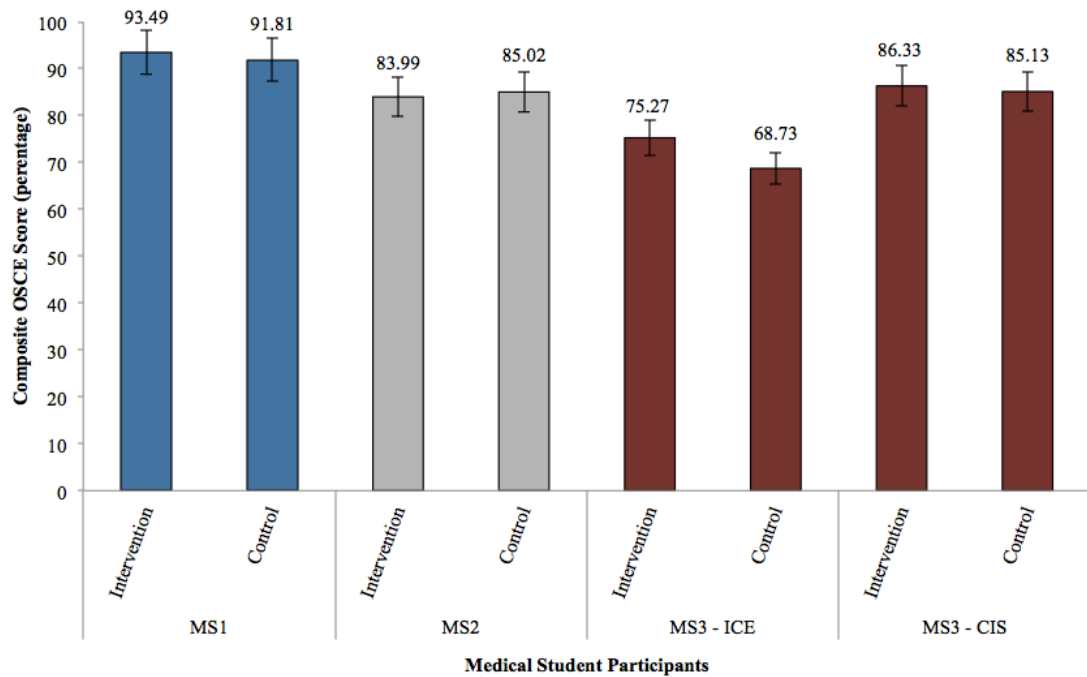
Composite OSCE scores for the MS1 and MS3 intervention groups were higher than the control groups, and those scores for the MS2 control group were higher than the intervention group; differences between intervention and control groups were not statistically significant among any class cohort. Error bars delineate the range of each composite OSCE score. CIS, Communication and Interpersonal Skills score; Control, control group (IUSM-E+IUSM-FW); ICE, Integrated Clinical Encounter score; Intervention, HFPS intervention group (IUSM-B); MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students.

In contrast to the MS1 intervention group outperforming the MS1 control group, the MS2 control group obtained slightly higher composite OSCE scores than the MS2 intervention group. The composite OSCE score for the MS2 intervention group was 83.99 ($SD = 5.73$) and was 85.02 ($SD = 4.14$) for the MS2 control group. However, this difference between the groups was not statistically significant ($t(26) = -.549$, $p = .588$, $d = 0.21$, observed difference: -1.02, 95% CI [-4.85, 2.81]). Note that the assumption of

normality was violated for the second-year OSCE comparison (intervention: skewness = -1.306; kurtosis = 1.918).

The composite OSCE ICE score for the MS3 intervention group was 75.27 (SD = 5.39) and was 68.73 (SD = 2.13) for the MS3 control group. The intervention group had higher composite OSCE ICE scores; although this difference came close to approaching statistical significance, it did not exhibit the .05 cutoff ($t(7)$ = 2.263, p = .058, d = 1.52, observed difference: 6.54, 95% CI [-0.29, 13.37]). Finally, the composite OSCE CIS score for the MS3 control group was 85.13 (SD = 2.61) and the composite OSCE CIS score for the MS3 intervention group was 86.33 (SD = 2.74), which was slightly higher than the control group. These composite OSCE CIS scores were essentially similar and the minimal difference between them was not statistically significant ($t(7)$ = .667, p = .526, d = 0.45, observed difference: 1.20, 95% CI [-3.06, 5.47]). Normality was violated for the third-year medical students and there was presence of an outlier.

These trends in the data indicate that first-year and third-year medical students from the intervention group had higher composite OSCE scores than their control counterparts, and the second-year medical students from the control group had higher composite OSCE scores than their intervention counterparts. It is worthy to note that the magnitude of the effect sizes were medium to large (except for the second-year medical student data demonstrated a small effect size). However, this interpretation is subject to the fact that no comparisons were found to be statistically significant and the small sample sizes of the medical student groups limit the statistical power associated with the t-tests.

Next, means and standard deviations of average self-efficacy ratings were calculated for each class cohort and independent-samples *t*-tests were conducted (Figure 5.2) to compare average self-efficacy ratings between the HFPS intervention group (IUSM-B) and the control group (IUSM-E and IUSM-FW).

Figure 5.2: Average self-efficacy ratings for the intervention (IUSM-B) and the control group (IUSM-E and IUSM-FW)
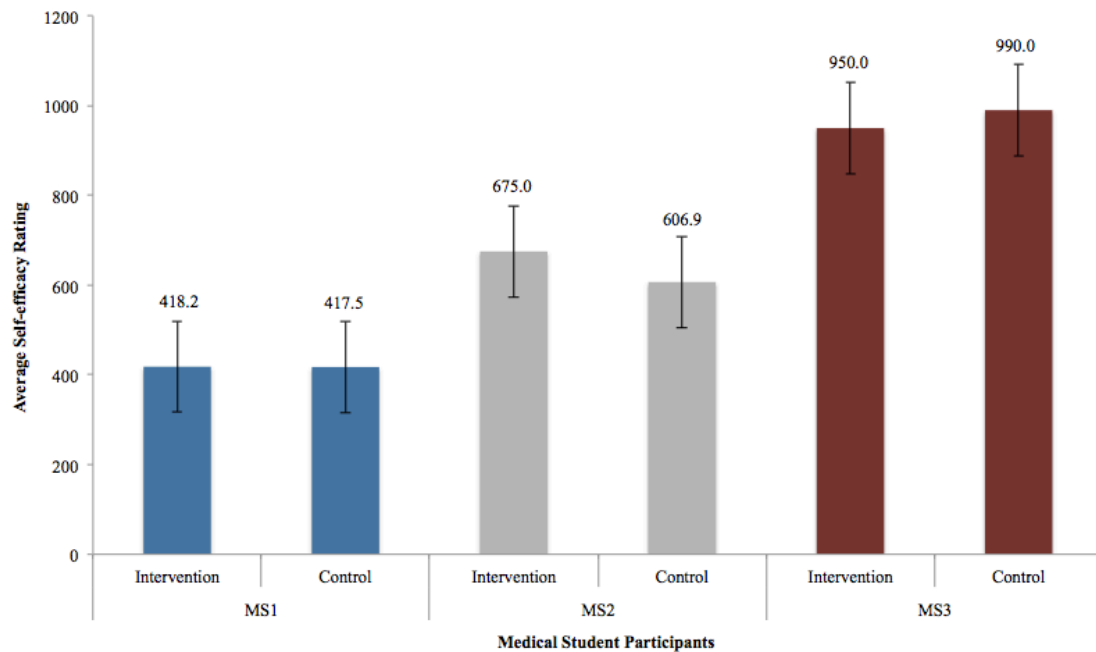
Essentially, there was no difference in average self-efficacy ratings between the MS1 and MS2 intervention groups had higher average self-efficacy ratings than the MS1 and MS2 control groups. However, the MS3 intervention group had lower average self-efficacy rating than the MS3 control group. Error bars delineate the range of each average self-efficacy rating. Statistical significance was not observed among any of the groups. Control, control group (IUSM-E+IUSM-FW); Intervention, intervention group (IUSM-B); MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students.

Average self-efficacy ratings were very similar for both intervention and control groups of first-year medical students. The average self-efficacy rating for the MS1 intervention group was 418.2 (*SD* = 106.3), and the average self-efficacy rating for the

MS1 control group was 417.5 ($SD = 135.3$). The difference in average self-efficacy ratings between the MS1 intervention and control groups was not statistically significant ($t(27) = .016$, $p = .987$, $d = 0.006$, observed difference: 0.74, 95% CI [-91.29, 92.76]). Assumptions for first-year medical students were satisfied, including: normality; homoscedasticity; and there were no outliers.

The average self-efficacy rating for the MS2 intervention group was 675.0 ($SD = 79.1$) and the average self-efficacy rating for the MS2 control group was 606.9 ($SD = 96.5$). The MS2 intervention group had higher average self-efficacy ratings; however, this difference was not statistically significant ($t(26) = 1.991$, $p = .057$, $d = 0.76$, observed difference: 68.1, 95% CI [-2.19, 138.44]). Note that the assumption of normality was violated for the second-year OSCE comparison (kurtosis = -1.129).

Lastly, the average self-efficacy rating for the MS3 intervention group was 950.0 ($SD = 121.0$) compared to 990.0 ($SD = 97.0$) for the MS3 control group, but this difference was not statistically significant ($t(7) = -.535$, $p = .609$, $d = 0.36$, observed difference: -40.0, 95% CI [-216.64, 136.64]). The normality assumption was violated (intervention: skewness = -1.430; kurtosis = 2.578; control: skewness = -1.598; kurtosis = 2.387) and there was one outlier.

These results indicate that there was essentially no difference in average self-efficacy ratings between the MS1 intervention and control groups, the MS2 intervention group had higher average self-efficacy ratings than the MS2 control group, and the MS3 intervention group had lower average self-efficacy ratings than the MS3 control group.

Pearson correlation coefficients between the composite OSCE scores and average self-efficacy ratings are shown in the following three tables (Tables 5.9-5.11) and figures (Figures 5.3-5.5). For the MS1 intervention and control groups, no variability was observed in the Communication and Interpersonal Skills (CIS) or Professionalism (Prof) components of the OSCE scores because all students received perfect marks for these two OSCE components. Therefore, these two variables were omitted. No statistically significant correlations were found between average self-efficacy ratings and the other components of OSCE performance among first-year medical students (Table 5.9). To visually inspect the data, the composite OSCE score was plotted against the average self-efficacy rating for first-year medical students in the intervention and control groups and is presented in Figure 5.3. As deduced by the tables and plots, the MS1 intervention group showed a very weak (negligible) positive correlation between composite OSCE scores and average self-efficacy ratings ($r = .066$, $p = .800$), whereas those in the control group exhibited a weak negative correlation between these two variables ($r = -.338$, $p = .283$). Thus, the data suggests that in the intervention group, higher average self-efficacy ratings were correlated with higher composite OSCE scores. In contrast, the control group demonstrated that higher average self-efficacy ratings were correlated to lower composite OSCE scores. Although statistical significance for these conclusions was not achieved in this data set, it should be acknowledged that the weak negative correlation between the Data-Gathering (DG) OSCE score and average self-efficacy rating in the MS1 control group was approaching significance ($r = -.540$, $p = .070$), and confirmed by visually inspecting the scatterplot of the control group.

Table 5.9: Pearson correlations among first-year medical student study variables

Group (*n*)		DG & SE	DOC & SE	Comp & SE
Intervention (*n* = 17)	Pearson *r*	-.016	.163	.066
	p-value	.950	.533	.800
Control (*n* = 12)	Pearson *r*	-.540	.007	-.338
	p-value	.070	.984	.283

Comp, Overall composite score (sum of weighted scores); DG, Data-Gathering weighted score; DOC, Documentation weighted score; SE, self-efficacy.

Figure 5.3: Scatterplots of Pearson correlations between average self-efficacy ratings and composite OSCE scores among first-year medical students
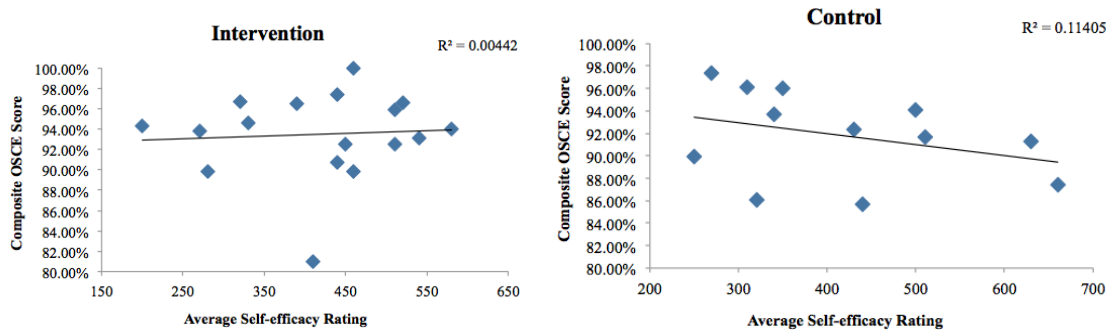
The MS1 intervention group exhibited a very weak positive correlation between composite OSCE scores and average self-efficacy ratings, while those in the MS1 control group demonstrated a weak negative correlation between these variables. These results may indicate that those in the intervention group had higher average self-efficacy ratings that correlated to higher composite OSCE scores while those in the control group had higher average self-efficacy ratings that correlated to lower composite OSCE scores.

Next, Pearson correlations for the MS2 data were computed and are presented in Table 5.10. There were weak negative correlations between average self-efficacy ratings and composite OSCE scores in the intervention group; however, these correlations were not statistically significant (*r* = -.357, *p* = .255). Similar findings occurred within the control group of very weak negative correlations between average self-efficacy ratings and composite OSCE scores that did not demonstrate statistical significance (*r* = -.242, *p*

= .366). However, one statistically significant moderate negative correlation did exist between average self-efficacy rating and the Communication Skills (CIS) OSCE score in the MS2 control group ($r = -.514$, $p = .042$). Again, scatterplots were prepared to visualize the data and demonstrated weak negative correlations between average self-efficacy rating and composite OSCE score for both the MS2 intervention group and for the MS2 control group (Figure 5.4). This alludes to higher average self-efficacy ratings being correlated with lower composite OSCE scores, and interestingly, this was found for second-year medical students within both the intervention group and the control group.

Table 5.10: Pearson correlations among second-year medical student study variables

Group (n)		PE & SE	DOC & SE	CIS & SE	DocFoc & SE	Comp & SE
Intervention (n = 12)	Pearson r	-.332	-.465	-.152	.147	-.357
	p-value	.292	.127	.638	.649	.255
Control (n = 16)	Pearson r	-.004	-.289	**-.514***	-.055	-.242
	p-value	.988	.277	.042	.840	.366

* Correlation is significant at $p < .05$.
CIS, Communication skills weighted score; Comp, Overall composite score (sum of weighted scores); DOC, Full history and physical documentation weighted score; DocFoc, Focused case documentation and diagnostic skills weighted score; PE, Physical exam skills weighted score; SE, self-efficacy.

Figure 5.4: Scatterplots of Pearson correlations between average self-efficacy ratings and composite OSCE scores among second-year medical students
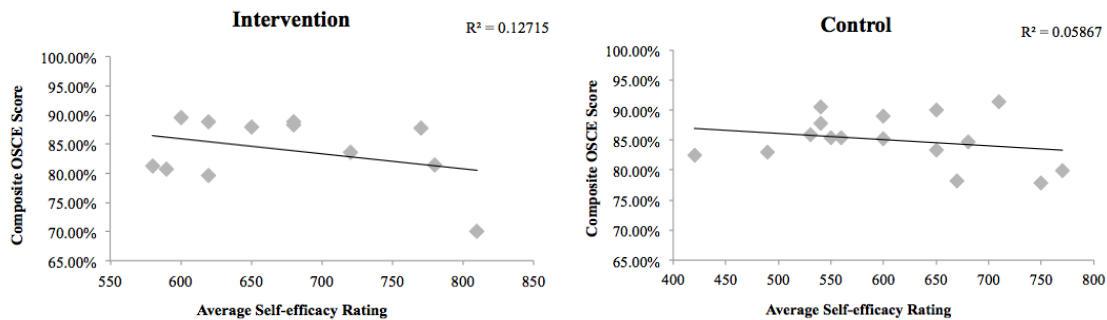
Weak negative correlations between composite OSCE scores and average self-efficacy ratings were found in the MS2 intervention group and very weak negative correlations between these variables were found in the MS2 control group. These findings may allude to higher average self-efficacy ratings being correlated to lower composite OSCE scores for second-year medical students in both the intervention and control groups.

Finally, Pearson correlations for third-year medical students were computed and are presented in Table 5.11. In the intervention group, there were very weak positive correlations between average self-efficacy rating and composite OSCE ICE scores and moderate positive correlations between average self-efficacy rating and composite OSCE CIS scores; however, these correlations were not statistically significant (ICE: r = .259, p = .673; CIS; r = .410, p = .493). In the control group, very weak negative correlations were found between average self-efficacy rating and composite OSCE ICE scores and strong negative correlations were found between average self-efficacy rating and composite OSCE CIS scores (ICE: r = -.050, p = .950; CIS; r = -.750, p = .250). Again, these correlations did not display statistical significance. These findings were confirmed from observation of the scatterplots (Figure 5.5). Therefore, when focusing on the intervention group, higher average self-efficacy ratings were correlated to higher composite OSCE ICE scores and to higher composite OSCE CIS scores. In contrast to

the control group, higher average self-efficacy ratings were correlated to lower composite

OSCE ICE scores and to lower composite OSCE CIS scores.

Table 5.11: Pearson correlations among third-year medical student study variables

Group (*n*)		ICE & SE	CIS & SE
Intervention (*n* = 5)	Pearson *r*	.259	.410
	p-value	.673	.493
Control (*n* = 4)	Pearson *r*	-.050	-.750
	p-value	.950	.250

CIS, Communication and interpersonal skills weighted score; Comp, Overall composite
score (sum of weighted scores); ICE, Integrated clinical encounter weighted score; SE,
self-efficacy.

Figure 5.5: Scatterplots of Pearson correlations between average self-efficacy ratings and
composite OSCE scores among third-year medical students
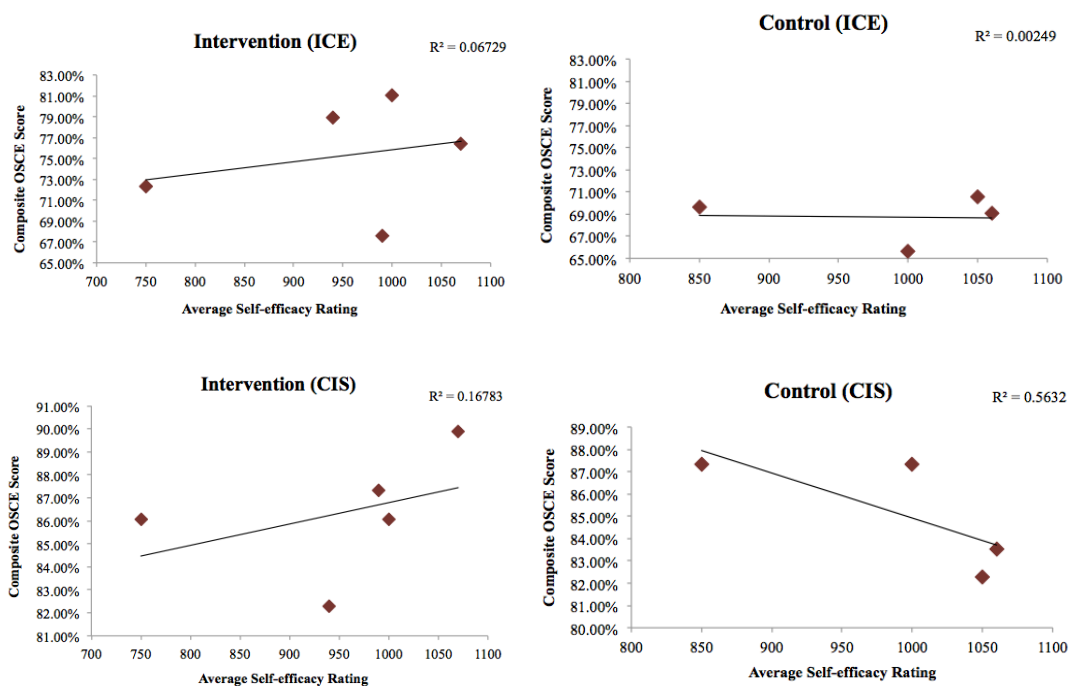
Very weak positive correlations between average self-efficacy ratings and composite
OSCE ICE scores and moderate positive correlations between average self-efficacy
ratings and composite OSCE CIS scores were found in the MS3 intervention group. Very
weak negative correlations been average self-efficacy ratings and composite OSCE ICE

scores and strong negative correlations been average self-efficacy ratings and composite OSCE CIS scores were discovered in the MS3 control group. These findings may show that higher average self-efficacy rating are correlated to higher composite OSCE scores in third-year medical students of the intervention group while higher average self-efficacy ratings are correlated to lower composite OSCE scores in third-year medical students of the control group. None of the preceding correlations were found to be statistically significant.

The last procedure that was conducted to answer Research Question 1 specifically looked at the impact of participating in HFPS on OSCE performance, while controlling for average ratings of self-efficacy, since perceptions of self-efficacy appeared to influence OSCE performance in the previous analyses. A one-way between subjects ANCOVA was performed to examine the effect of HFPS exposure on composite OSCE scores while controlling for average self-efficacy rating. In the MS1 group, exposure to HFPS did not show a significant difference in terms of composite OSCE score after controlling for average self-efficacy rating, $F(1, 26) = 1.162$, $p = .291$, $\eta^2 = .043$. Additionally, average self-efficacy rating was not a significant covariate, $F(1, 26) = .336$, $p = .567$, $\eta^2 = .013$.

The covariate, average self-efficacy rating, for the MS2 group was not significantly related to performance on composite OSCE scores, $F(1, 25) = 2.201$, $p = .150$, $\eta^2 = .081$. There was no statistical significance of HFPS exposure on composite OSCE scores after controlling for the effect of average self-efficacy ratings for the MS2 group, $F(1, 25) = .000$, $p = .987$, $\eta^2 = .000$.

For the MS3 group, HFPS exposure did not show a significant difference in composite OSCE ICE scores when removing the impact of average self-efficacy rating, $F(1, 6) = 4.786$, $p = .071$, $\eta^2 = .444$. Additionally, average self-efficacy rating was not a significant covariate for this model, $F(1, 6) = .231$, $p = .648$, $\eta^2 = .037$. When examining

the ANCOVA for the composite OSCE CIS scores, average self-efficacy rating was not found to be a statistically significant covariate, $F(1, 6) = .001$, $p = .977$, $\eta^2 = .000$. There was no statistically significant effect of HFPS exposure on composite OSCE CIS scores after controlling for average self-efficacy rating, $F(1, 6) = .359$, $p = .571$, $\eta^2 = .057$.

None of the ANCOVA models for any medical class cohort yielded statistical significance. While there was a large effect size discovered in the composite OSCE ICE scores of the third-year medical students, meaning that exposure to HFPS explained almost half (44.4%) of the variance in composite OSCE ICE scores when controlling for average self-efficacy rating, it should be noted that the sample sizes are small here. A future study with larger sample sizes should be done to see if these trends are replicated.

Research Question 2 Results

As previously described in the methodology section of this chapter, second-year medical students in the intervention group (IUSM-B) received scores for HFPS throughout the year, and these scores were averaged for each medical student to create a single composite simulation score for analysis. The specific HFPS that second-year medical students participated in at IUSM-B in the IUBIPSC has been previously discussed in Chapter 3. Two ordinary least squares regression (OLS) models were calculated to predict composite OSCE score (OLS Regression Model 1) and average self-efficacy rating (OLS Regression Model 2) based on HFPS score among the 12 IUSM-B second-year medical students who participated in this study.

For OLS Regression Model 1, which investigated the extent that HFPS score could predict average self-efficacy rating, a non-significant regression equation was

found ($F(1, 10) = .001$, $p = .981$). Statistically, none of the variation in average self-efficacy ratings can be attributed to HFPS scores in this data set ($R^2 = .000$ and an adjusted $R^2 = -.100$). Hence, performance during simulations (as measured by HFPS performance scores) did not make a significant change in the average self-efficacy ratings.

For OLS Regression Model 2, which investigated the relationship between composite OSCE score and HFPS score, a non-significant regression equation was found ($F(1, 10) = 2.305$, $p = .160$), with an R^2 (also known as the coefficient of determination) of .187 and an adjusted R^2 of .106. Since adjusted R^2 should be interpreted for smaller sample sizes (Grande, 2014), approximately 10.6% of the variation in composite OSCE scores is explained by HFPS exposure (according to Grande (2014), ideally 30% is desired). The model predicted that composite OSCE score increased 1.757 points for each point scored while participating in HFPS, therefore, performance in HFPS as measured by simulation scores did not make a significant change to the composite OSCE scores. However, if this pattern holds true for larger sample sizes, this lack of statistical significance seen in this study is likely due to the small sample size limitation.

Questionnaire Analysis Results

Frequency distributions of Dreyfus model ratings are presented in Figure 5.1. First-year medical students in both the intervention group (IUSM-B) and the control group (IUSM-E and IUSM-FW) were fairly consistent with their ratings, selecting 'Novice' or 'Advanced beginner,' with the exception of one participant in the control group (IUSM-FW) ranking themselves as 'Proficient.' This individual also had very high

ratings of self-efficacy (860 compared to an average of 497 for other control MS1s), but low composite OSCE score (79.9% out of 100%, see Figure 5.1), alluding to a potential disconnect between perceived and actual ability.

A similar occurrence was seen in the second-year medical students of both the intervention and control groups. The second-year medical students tended to select stages at the lower end of the updated version of the Dreyfus scale, including 'Novice,' 'Advanced beginner,' and 'Competent' with average self-efficacy rating of 828. However, 'Proficient' was selected by two second-year medical students in the intervention group (IUSM-B): for one MS2 the average self-efficacy rating was 984 and OSCE was 87%; for the other MS2 the average self-efficacy rating was 1090 and OSCE was 70%. Additionally, 'Expert' was chosen by one second-year medical student in the control group (IUSM-E). This individual had an average self-efficacy rating of 1050 and OSCE was 74%.

Third-year medical students generally ranked themselves as 'Advanced beginner' or 'Competent,' (with average self-efficacy rating of 980), except for two third-year medical students in the control group (IUSM-FW) who chose 'Proficient.' One student had an average self-efficacy rating of 1050 and OSCE score of 70% (ICE) and 82% (CIS); the other student had an average self-efficacy rating of 1160 and OSCE was 69% (ICE) and 92% (CIS).

Thus, most medical students in all groups tended to rank themselves appropriately, according to the proposed ranking that medical students should selected from the Dreyfus Model of Skill Acquisition. First-year and second-year medical students tended to rank themselves closer to the 'Novice' and 'Advanced beginner' stages, while

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third-year medical students were aware of their increased expertise and tended to select

'Advanced beginner' and 'Competent.' Exceptions tended to come from some of those in

the control group (and two second-year medical students in the intervention group) who

ranked themselves at much higher stages than would be expected of a medical student at

this stage in their education.

However, it became apparent while conducting the interviews (see Chapter 6),

some of these medical students struggled to discern the Dreyfus ranking question

properly, which may have impacted their choice, and thus the overall distribution of

ratings.

Figure 5.6: Frequency distribution of Dreyfus model ratings among medical students
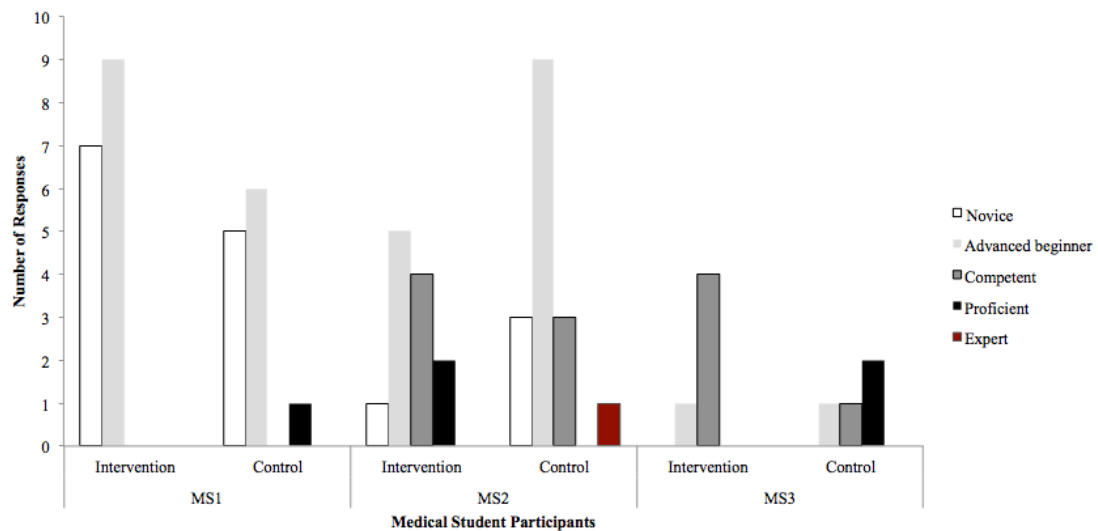
Most medical students in both the intervention and control groups tended to rank their perceived ability appropriately according to the Dreyfus Model of Skill Acquisition for medical students as proposed by Batalden et al. (2002). There were a few exceptions in both groups. Control: control group (IUSM-E+IUSM-FW); Intervention: intervention group (IUSM-B); MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students.

The medical students from both the intervention and control groups who participated in this study were asked to rank five instructional interventions based on perceived helpfulness for learning clinical skills. The five instructional interventions included: high-fidelity patient simulation (HFPS), Standardized Patients (SPs), real patients (RP), part-task trainers (PT), and computer-based modules (CB). Medical students were asked to rank order their preferred instructional strategy from 1, most helpful for learning clinical skills, to 5, least helpful for learning clinical skills. From the weighted averages, the preferred teaching strategy among each class cohort is presented in Table 5.12.

Table 5.12: Rankings of five instructional strategies for learning clinical skills

Medical Class		HFPS	SP	RP	PT	CB
MS1	Intervention	2	1	3	4	5
	Control	3	2	1	4	5
MS2	Intervention	2	3	1	4	5
	Control	3	2	1	4	5
MS3	Intervention	2	4	1	3	5
	Control	2	3	1	4	5

Rankings: 1 = Most helpful to 5 = Least helpful; Frequencies of rankings for each strategy were calculated; the first-place values were multiplied by 5; second-place values were multiplied by 4; third-placed values were multiplied by 3; fourth-placed values were multiplied by 2; and fifth-placed values were multiplied by 1 based on weighted averages. Weighted values were then summed across each feature, and then divided by the total number of respondents, producing a final ranked score. This procedure was also done by Cendan and Johnson (2011). CB, computer-based modules; Control, IUSM-E and IUSM-FW groups not exposed to simulation; HFPS, high-fidelity patient simulation; MS1, first-year medical students; MS2, second-year medical students; MS3, third-year medical students; Intervention, IUSM-B Group exposed to simulation; PT, part-task trainers; RP, real patients; SP, Standardized Patients.

When considering the average rankings, it is apparent that the intervention group consistently ranked HFPS higher than the control group in the MS1 and MS2 groups; this

finding could imply that those medical students from the intervention group recognized the value of HFPS for learning clinical skills. Since the MS1 and MS2 medical students within the control cohorts were not exposed to HFPS, they may not have seen the value of this instructional adjunct to their education. By the time medical students entered their third-year, the control group began ranking HFPS as high as those in the intervention group. Perhaps now that these medical students had begun rotations with actual patients, they began to see the value of HFPS in obtaining relevant clinical experience in a low-risk scenario. It is also interesting to note that all students consistently ranked computer-based modules as the least helpful for learning clinical skills. Reasons for this tended to center around the experiential and realistic elements imparted by the other four strategies, which is not afforded by computers, and is further explained in the interviews presented in Chapter 6. Another interesting, although slightly alarming, trend was seen in the high rankings of value in real patients for learning clinical skills. One would envision that for actually learning clinical skills, a more formative assessment method that did not bear the risk of injury, or worse, to real patients would be preferred.

All medical students who participated in this quantitative study were asked on the questionnaire to participate in a follow-up interview, described in more detail in Chapter 6. The interviews asked participants to elaborate on their choice of ranked instructional interventions in order to further extend and explain these quantitative findings, and answers alluded to the medical students' preferences for practicing and gaining experience from "the real thing" since they will be working with real patients in their future careers.

The questionnaire also asked respondents to indicate their perceived feelings of preparedness to successfully complete the OSCE (Figure 5.7). The single-option item was on an ordinal scale, and included: 'completely unprepared,' 'moderately unprepared,' 'slightly unprepared,' 'slightly prepared,' 'moderately prepared,' and 'very well prepared'. Based on Figure 5.7, first-year medical students from the intervention group generally found themselves to be 'moderately' and 'very well prepared' for the OSCE. In contrast, first-year medical students from the control group tended split equally between 'moderately unprepared' and 'moderately prepared.' The majority of second-year medical students from the intervention group indicated feeling 'moderately prepared' for the OSCE, with a few second-year medical students from the control group indicating feeling 'very well prepared.' Lastly, third-year medical students from the intervention group were equally split among feelings of being 'slightly unprepared,' 'slightly prepared,' 'moderately prepared,' and 'very well prepared.' The majority of third-year students from the control campuses felt 'very well prepared' for the OSCE.

These findings suggest that first-year medical students from the intervention group felt more prepared to successfully complete the OSCE compared to first-year medical students from the control group, while second-year medical students from the control group felt more prepared to successfully complete the OSCE compared to second-year medical students from the intervention group. Third-year medical students, being farther along in their programs and well versed in the nuances of taking the OSCE from their previous two years, felt relatively similar about successfully completing the OSCE, regardless of if they came from the intervention or the control group. However, those third-year medical students from the control campus tended to rate their feelings of

successfully completing the OSCE as higher than that of the third-year medical students from the intervention group. These trends may hold for larger groups; however, the issues associated with OSCE preparation are discussed in Chapter 6.

Figure 5.7: Summary of perceived preparedness for the OSCE
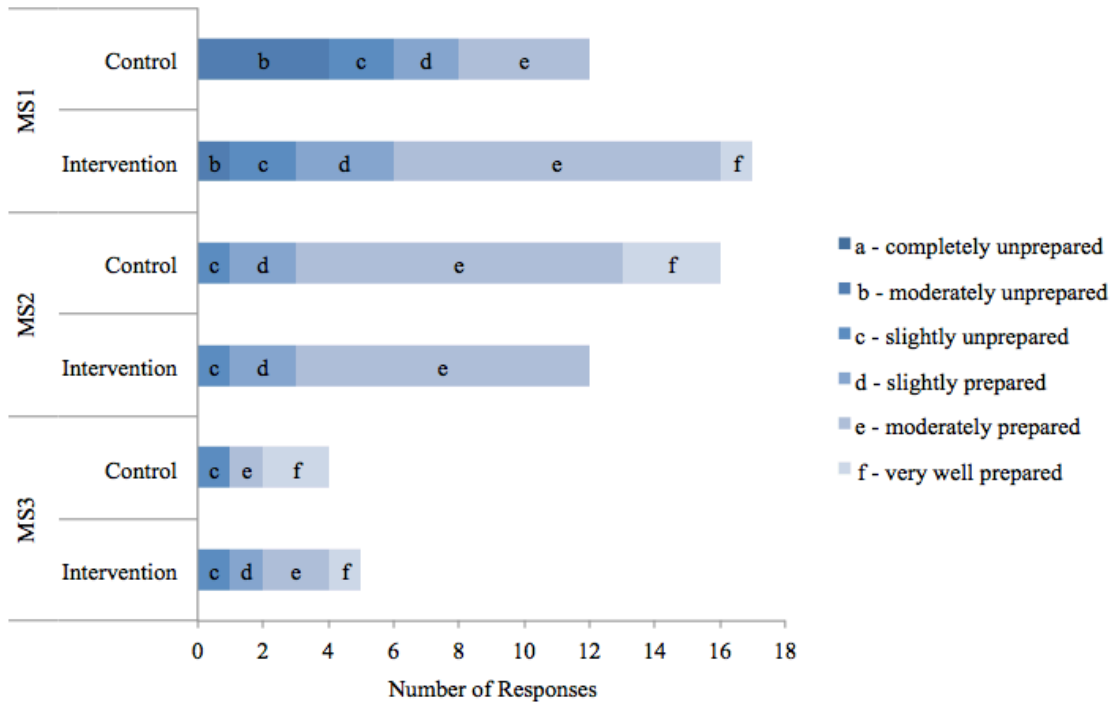
Finally, the IUSM-B questionnaire had one additional question related to benefits associated with participating in HFPS. Respondents were asked to select the single most beneficial aspect of participating in HFPS from a pre-determined list generated from the literature review (Chapter 2) and pilot study (Chapter 4). The questionnaire presented seven options for the IUSM-B medical students to select, which included: 'ability for repeated practice;' 'exposure to a wide variety of patient cases;' 'debriefing with a faculty member after the simulation;' 'opportunities to integrate basic science knowledge with clinical practice;' 'working with nursing students during interprofessional education

(IPE) simulations;' 'I did not find simulation beneficial to my medical education;' and

'Other, please describe.' The frequency of each IUSM-B medical class cohort is

presented in Figure 5.8.

Figure 5.8: Frequency of medical students' perception regarding the single most
beneficial aspect of HFPS experienced at the IUBIPSC
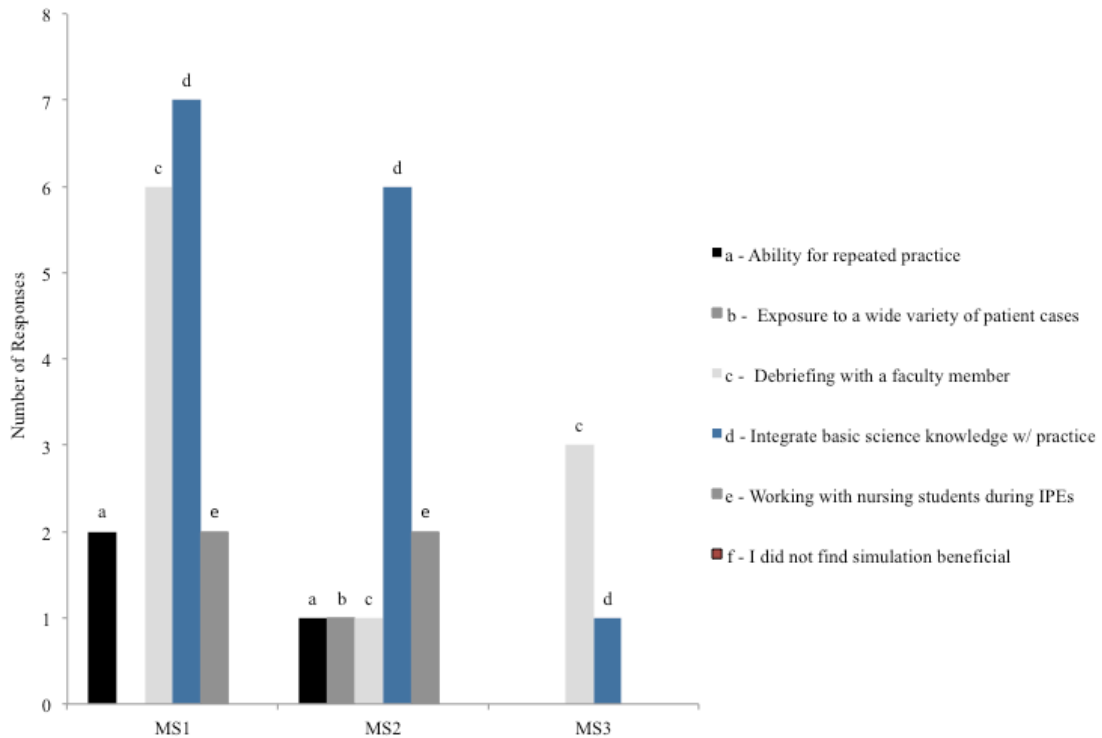
MS1, first-year medical students; MS2, second-year medical students; MS3, third-year
medical students.

First-year medical students generally found either the debrief or integration aspect

of HFPS as the most beneficial. Second-year medical students overwhelmingly found

integration beneficial, while third-year medical students found the debrief beneficial.

Reasons for these selections are discussed in Chapter 6.

Discussion

The overall goal of the first two research questions of this dissertation was to quantify the impact of HFPS on clinical competence, assessed as performance on the OSCE, and on clinical self-efficacy. While there have been several studies investigating the utility of HFPS for the performance of isolated tasks and skills, such as thoracocentesis (Barsuk et al., 2017), laparoscopic skills (Cosman et al., 2007), and central venous line insertion (Barsuk, McGaghie, Cohen, O'Leary, & Wayne, 2009), few studies (in medical or nursing education literature) have assessed the overall impact of HFPS on performance-based evaluations, such as the OSCE (Hsieh, Cheng, & Chen, 2014; Hsu et al., 2015; Mompoint-Williams et al., 2014). Acknowledging that small samples sizes obtained for this portion of the study limit conclusive interpretations to be drawn, several trends in the data warrant attention.

The first research question asked, "What is the relationship between ratings of clinical self-efficacy and clinical competence, as measured by scores on final performance-based assessments (OSCE), among first-year, second-year, and third-year medical students exposed to HFPS compared to those who are not exposed to this intervention?" Little difference and non-statistically significant findings between the first-year medical students in the control and intervention groups with respect to composite OSCE score and average self-efficacy rating were found. Very weak positive Pearson correlations between average self-efficacy ratings and composite OSCE scores were found in the first-year intervention group while moderate negative correlations were found between these variables in the first-year control group. These findings suggest that early exposure to HFPS has a weak positive impact on the OSCE scores of those in the

intervention group, while lack of exposure to HFPS may have negatively impacted those in the control group. This is supported by citations of HFPS used to acquire a measurable increase in practical clinical skills training (Ha, 2016; Reilly & Spratt, 2007; Scalese et al., 2007).

The minimal difference observed between the first-year intervention and control groups may relate to the fairly similar curricula experienced by the first-year medical cohorts. As described in Chapter 3, first-year medical students at IUSM-B participate in just two simulations, a single CPR simulation in the fall semester and one IPE simulation in the spring semester. Otherwise, the programs between the campuses are similar with students experiencing training with SPs, preceptor shadowing, and small group learning sessions (e.g., team-based learning and problem-based learning). Therefore, it is not surprising that the quantitative data was similar between the first-year intervention and control groups.

The simulation schedule rapidly increases during the second-year at IUSM-B, where students participate in six simulations (previously described in detail in Chapter 3). When comparing the second-year medical student composite OSCE scores, the control group outscored the intervention group. All second-year medical students demonstrated a weak or moderate negative correlation between their perceived self-efficacy and composite OSCE score. These findings may indicate that second-year medical students inaccurately assess their ability, regardless of being exposed to multiple simulation scenarios. However, interpretations are made cautiously as neither of the differences in OSCE or self-efficacy rating was statistically significant.

Additionally, OLS regression models were used to investigate Research Question 2 asking, "To what extent do simulation performance scores predict ratings of clinical self-efficacy and clinical competence, as measured by scores on the final OSCE, among second-year medical students exposed to HFPS?" HFPS experience was not found to predict OSCE score (with only approximately 10% of the variance in OSCE score explained by HFPS) or clinical self-efficacy. This finding is surprising given that feedback (in the form of the debrief) following hands-on experience during HFPS may help learners to recalibrate perceived levels of confidence toward a more accurate self-assessment of ability (Liaw et al., 2012). The lack of findings may relate to the second-year class sampled from, with more research needed to verify if another medical class may show an impact on self-efficacy and OSCE score from HFPS exposure. Since several more HFPS scenarios are experienced during the second year, perhaps the IUSM-B medical students experienced feelings of under-confidence given so much clinical experience at an early stage in their education, or perhaps a larger sample could find a stronger association.

The disconnect between HFPS impacting perceptions of ability and actual performance in external reality has been cited in the literature. For instance, Liaw et al. (2012) conducted a study of a randomized control trial of 49 senior nursing students to investigate if self-reported confidence levels and tests of knowledge were indicators of performance in a deteriorating patient simulation-based assessment. The researchers discovered an alarming finding in the potential danger of HFPS experience to lead to overestimation of self-ability without a concomitant increase in clinical performance. They concluded that practical, hands-on HFPS training may have led to enhanced

confidence, which could have occurred with the second-year IUSM-B medical students in the present study.

The phenomenon of overestimating one's ability to successfully perform when compared to external measures of competence is described in the literature, most notably by Kruger and Dunning (1999). Referred to as the "unskilled and unaware effect," (Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008), the "Dunning-Kruger effect" (Kruger & Dunning, 1999), or "blissfully incompetent," (Williams, 2004), and explains that not only do low-performers tend to overestimate their ability, but they also lack the awareness to recognize deficits in their knowledge (i.e., they lack metacognition). For instance, 74 first-year and second-year medical students were asked to predict their anatomy practical grade immediately after taking the examination (Sawdon & Finn, 2014). Save for a small mid-range group, students were unable to accurately predict their exam performance, with a strong statistically significant relationship in poor performers overestimating their ability and high achievers underestimating their ability. The findings by Sawdon and Finn (2014) are additionally alarming considering that previous research has suggested self-assessment predictions are more accurate when made after retrieval of content material (Pierce & Smith, 2001)

However, a study conducted on 91 junior and senior undergraduate psychology students reported that the "unaware" aspect may not be entirely accurate (Miller & Geraci, 2013). Low-performing students did exhibit overconfidence in score prediction compared to high-performing students in their study; however, the low-performing students also demonstrated lower confidence in their predictions, implying that the students may have some awareness of their lack of metacognitive insight. It is impossible

to know in the present study how confident the IUSM medical students were in their OSCE performance predictions, but this should be an area of future studies in order to determine if the low-performing medical students with high evaluations of self-efficacy are truly unaware, or if they have some inclination of their inability.

The unskilled yet unaware effect may have also manifested in the questionnaire item related to the revised Dreyfus Model of Skill Acquisition. Recall, the Dreyfus Model of Skill Acquisition is a popular scale in self-efficacy literature that lists ascending stages that learners pass through on their way toward obtaining competence, including: novice, advanced beginner, competent, proficient, expert, and master.

The novice stage is described as a first-year medical student at the beginning of their education; advanced beginner is considered a junior medical student; a medical resident is labeled competent as they can set up patient plans; the proficient stage is associated with a specialist doctor; and the expert stage is considered a mid-career physician (Batalden et al., 2002). Note that the authors did not identify the master stage in the development of a physician. Given these suggested rankings, it appears that some medical students in this study consistently overrated their Dreyfus ratings. However, follow-up interviews did reveal some confusion with the question and inaccurate interpretation, which confound these results.

None of the other correlations were statistically significant in this study; however, the fact that all control groups, from first-year through third-year, showed negative correlations between self-efficacy ratings and OSCE scores ranging from weak to strong is indicative of a pattern in the data. These students may have difficulty accurately self-assessing their current ability to successfully perform clinical skills. Several studies have

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concluded no or little correlation exists between learner competence and self-efficacy (Arnold et al., 1985; Blanch-Hartigan, 2011; Woolliscroft et al., 1993). For instance, in a study investigating medical students' accuracy of self-assessment of perceived level of neuroanatomical knowledge, results demonstrated that higher-achieving students underestimated their ability while underachieving students tended to overestimate their ability on an objective knowledge assessment (Hall et al., 2016). The authors concluded that the medical students were unable to accurately assess their neuroanatomy knowledge and suggested that quality, structured feedback will improve neuroanatomy education.

However, the proceeding interpretations of HFPS experience on medical student OSCE performance should be made cautiously as statistical significance was not achieved in this study. In support of these results, self-efficacy has not previously been significantly correlated to OSCE performance (Mavis, 2001). While quantitative effects on medical student OSCE were not observed in this analysis, positive effects on affective outcomes such as team-based communication skills and overall clinical confidence were claimed by IUSM-B medical students of the intervention group during interviews (see Chapter 6) and faculty and staff perceptions confirmed this interpretation of the IUSM-B medical students exposed to HFPS compared to those medical students in the control group (see Chapter 8 for faculty and staff interviews). Jolly and colleagues (1996) observed little to no correlation among clinical skills and OSCE performance, although they noted that performing skills at least once conferred a measurable increase in expertise. Likewise, Mavis (2001) and Hsu, Chang, and Hsieh (2015) found no significance of HFPS on OSCE performance.

The self-efficacy results from this dissertation research are consistent with the literature. When looking at all class cohorts, medical students indicated feeling more efficacious of their ability from first-year through third-year. Blanch-Hartigan (2011) discovered through a meta-analysis that self-assessed performance improved with more years in medical school. While comparing medical student to preceptor evaluations, Huang and Grigoryan (2017) were not surprised when second-year medical students reported lower self-assessment ratings than the third-year medical students; the authors concluded that self-assessment skills improve with more experience while advancing through medical school. Likewise, Harrell and colleagues (1993) identified that progression through the curriculum was positively correlated with confidence in a primary care clerkship among 60 third-year medical students.

Progression through the curriculum may also have explained why second-year IUSM-B medical students had higher self-efficacy ratings than the second-year control group, while third-year IUSM-B medical students had lower self-efficacy ratings than the third-year control group. As previously stated, second-year IUSM-B medical students experience more HFPS so they are exposed to more cases and skills at an early stage in their curriculum, which could have led to higher perceived self-efficacy. Third-year IUSM-B medical students are exposed to HFPS as well as real world clinical exposure during clerkships, so they may have adjusted their perceived ability to a lower level given both the HFPS exposure in addition to real world exposure.

Additional data analysis was performed on questionnaire items in Section 2 regarding perceptions of clinical skills training and HFPS (presented to the intervention group only). General patterns in support of HFPS were apparent after analysis of the

ranking question of five instructional strategies for learning clinical skills. The weighted averages revealed that the majority of medical students (from both the intervention and control groups) found computer-based modules the least helpful for learning clinical skills. The benefit of interacting in an immersive HFPS environment with a manikin compared to less interactive computer-based simulations is consistent with the literature (Cendan & Johnson, 2011; Harris et al., 2014; Steadman et al., 2006). However, a study comparing virtual patient simulation to HFPS did not discover a difference in assessing and managing patients with clinical deterioration, and given the high cost of HFPS, the author advised for training with computer simulation (Liaw et al., 2014).

Those in the intervention group who were exposed to HFPS within the IUBIPSC consistently marked HFPS higher than those in the first-year and second-year control groups with little to no exposure with HFPS. This may indicate that medical students within the intervention group (whether they were first-year, second-year, or third-year) recognized the value and utility of HFPS while the control groups, not having exposure to the immersive environment or patient manikin, did not recognize the value in this educational strategy. However, when the medical students within the control group reached their third-year, they began ranking HFPS higher. This may have been due to the increased exposure to the clinic and patient management in this later stage of medical education; these third-year medical students may have a more sophisticated understanding of the value of low risk practice with HFPS to aid in the development of their clinical skills with real patients. This pattern is not surprising as previous research has indicated that continuous repeated exposed to HFPS is required for learners to acclimate and overcome the novelty of HFPS (Dotger et al., 2010).

Supportive data from the present study includes an interview with a third-year medical student from the control group (see Chapter 6). This student did explain that they were exposed to a HFPS center near their campus, however they did not find much value in the experience as they had only had a few sessions and still believed that there is no substitute for real patients, claiming that first-year and second-year medical students should have more practice with real patients early on in their medical careers.

The most unexpected, and slightly alarming, result of the ranking question analysis was how many medical students, across both the intervention and control groups, and all school years, selected 'real patients' as the most helpful for learning clinical skills. A possible explanation for selecting 'real patients' is grounded in the qualitative interview data (see Chapter 6). When medical students were asked to elaborate on their choice of rankings during follow-up interviews, students reiterated a common statement of "nothing can replace real practice with real patients" and the idea of direct transfer of knowledge while working with real patients to future patients. Only the first-year medical students in the intervention group ranked real patients at a lower level. HFPS literature continually reiterates the benefit of simulation training to impart learners with experience while maintaining patient safety (Bradley, 2006; Feather et al., 2016; Henneman et al., 2007; Reising et al., 2011; Scalese et al., 2007); however, the reality of practicing on a real patient with the potential to injury them seemed to not have as great an impact on the students in this study as would be expected.

Woolliscroft and colleagues (1993) claimed that, "arguably, the most important skill medical educators need to cultivate in nascent physicians is the ability to accurately evaluate personal strengths and weaknesses" (p. 285). However, do medical students

cultivate the ability to accurately assess their own knowledge and skills during their education? The results of this research allude to the fact that some of these students may have an inaccurate ability to self-assess their actual competence.

While rigorously assessing the utility of HFPS in medical education is still a challenge, this portion of the research attempted to quantify the impact of this pedagogical adjunct. Overall, the trends in the data suggest that medical students in both the intervention group exposed to HFPS and control group with little to no exposure to HFPS had comparable levels of knowledge and were academically similar with respect to OSCE performance. At a minimum, it appears that experiencing HFPS is not academically detrimental to any medical class year. Analysis of questionnaire data (e.g., the ranking question of instructional strategies) as well as qualitative interviewing (see Chapter 6) indicated that medical students from the intervention group, including first-years with little exposure to HFPS, recognized the positive effects and importance of the experience that they received from participating in HFPS on their overall acquisition of clinical skills and development of becoming a physician. Continued research is needed to fully articulate the impact of HFPS during medical education.

Demographic data was collected on the questionnaire; however, the small sample size limited the feasibility of investigating differences among these variables. Future iterations of this research including a more robust sample will permit further analysis with regard to demographic variables such as gender, age, and ethnicity. For instance, a propensity score matching analysis can be conducted to match demographic data between groups to estimate the effect of an intervention by accounting for covariates such as demographics.

This chapter focused on the quantitative impact of HFPS on medical students to investigate Research Questions 1 and 2. The next chapters will examine the qualitative portions of this research on both medical students (Chapter 6) and medical residents (Chapter 7) through two different qualitative methodological approaches: qualitative content analysis for medical student interviews and Q-methodology for medical residents.

CHAPTER 6: QUALITATIVE RESULTS AND ANALYSIS OF MEDICAL

STUDENT PERCEPTIONS REGARDING THE UTILITY OF HIGH-FIDELITY

PATIENT SIMULATION

The previous chapter presented the quantitative analyses of this dissertation research regarding the utility of high-fidelity patient simulation (HFPS) in medical education. Several previous quantitative studies were also presented that assessed the statistical significance of HFPS in various healthcare education populations (Ha, 2016; Hsieh et al., 2014; Hsu et al., 2015; Mompoint-Williams et al., 2014; Reilly & Spratt, 2007; Scalese et al., 2007). However, in order to holistically capture the impact of HFPS, including the personal experiences, subjective interpretations, and specific nuances that ultimately affect learning, one must turn to other assessment methodologies – namely, qualitative analysis. Qualitative researchers have investigated HFPS in healthcare education through a variety of data collection instruments and distinct methodologies, including: focus group transcripts coded using qualitative content analysis (Feather et al., 2016), open coding of interview transcripts (Botma, 2014), and grounded theory approaches for data triangulation among four data sources, including researcher observation memos, classroom photographs, tutor feedback, and an exit survey (McCoy et al., 2016).

For instance, Coombs and colleagues (2017) described the design and evaluation of a simulation-based curriculum for 81 first-year medical students at Perdana University Graduate School of Medicine (in collaboration with Johns Hopkins University School of Medicine). When analyzing the perceptions of the simulation-based curriculum, thematic

analysis of open-response items from a survey yielded themes that included a positive sense of learner engagement, an appreciation of the interactive nature of the simulation modules, and the students' desire for more time to participate at each simulation station. In another qualitative study, six third-year, four fourth-year, and 12 fifth-year medical students (note that this study was conducted in the United Kingdom where medical school is five years, rather than four years as in the United States) participated in two simulated clinical skills tasks: a wound closure simulation and a urinary catheterization simulation (Kneebone et al., 2005). Through thematic analysis of written observational data and semi-structured interviews, the researchers discovered that the participants positively viewed the simulations as educationally useful and the simulations were advantageous for safely acquiring training on the clinical procedures.

Therefore, the perceptions of medical students regarding HFPS is a continued pursuit, and Research Question 3a was proposed, which stated, "How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?"

Methodology

An abbreviated methodology will be presented in this chapter. First, population and recruitment methods will be discussed, followed by a description of the questionnaire administered to medical students, the interview methodology will be outlined, and the procedure for the directed approach to qualitative content analysis (QCA) of the medical student interviews and open-response item from the questionnaire will conclude this

section. See Chapter 3 for a more comprehensive description of the methodology utilized to investigate Research Question 3a.

Population, Sample, Questionnaire Description, and Interview Methodology

The total class population sizes of the intervention and control groups may be found in Table 6.1. Interviews were conducted with medical students at the intervention campus (IUSM-B) and the control campuses (IUSM-E and IUSM-FW) who selected "Yes" on the questionnaire, indicating that they would be willing to participate in an interview regarding their OSCE testing experience and general reflections of the effectiveness of their clinical training within their medical program (including HFPS for the intervention group interviewees). After distribution of interview invitations and subsequent scheduling, those included in the qualitative interviewing portion of this research, and thus considered the sample, may be found in Table 6.1.

Table 6.1: Indiana University School of Medicine (IUSM) medical student population
             and sample sizes

Group		Population Sizes	Number Participated in Study (completed questionnaire)	Number Indicated "Yes" to an Interview	Number Interviewed	Average Interview Time (mins)
IUSM-B	MS1	36	17	12	7	22
	MS2	36	12	6	2	20
	MS3	8	5	4	3	21
IUSM-FW	MS1	32	12	8	2	31.5
	MS2	29	9	5	3	15
	MS3	12	4	4	1	14
IUSM-E	MS2	23	7	4	3	13

Description of the Questionnaire

The first portion of the "Medical Student Self-Efficacy and Simulation Perception Questionnaire" (Appendix A and Appendix B) was used for quantitative analysis (see Chapter 5). The second portion of the questionnaire consisted of items related to perception data, including an open-response item asking participants to explain their overall impressions about their experience participating in simulations at the IUBIPSC, which is presented in the results section of this chapter.

The final dichotomous (yes/no) item of the questionnaire asked participants if they would be willing to participate in a brief follow-up interview regarding their OSCE testing experience and overall reflections of the effectiveness of their clinical training. These follow-up interviews gave medical students the opportunity to reflect on their performance and re-evaluate their original self-assessment from their questionnaire responses. Those medical students who indicated a willingness to participate in a follow-up interview were contacted at a time that depended on the specific campus and year of medical school, which was approximately one month after taking their final, summative performance-based assessment (OSCE) for their respective medical school year. Based on the administration of the OSCE (Table 3.3), first-year and second-year medical students from IUSM-B, IUSM-E, and IUSM-FW were invited for the interview portion of this research between June 19 and June 20, 2017. Third-year medical students from IUSM-B and IUSM-FW were invited to interview between July 14 and 15, 2017. Everyone who initially agreed to an interview was not interviewed, as seen from the numbers in Table 6.1.

Interview Methodology

Each medical student was interviewed once, using a semi-structured interview format of predetermined open-ended questions (Appendix E). Some questions were specific to the group that the medical students were within (e.g., those within the intervention group were asked questions about the IUBIPSC; those within the control group were asked if they ever had a chance to work with nursing students at their respective campus). The semi-structured nature of the interview questions permitted the exploration of additional questions that arose organically throughout the conversation. Medical students were given the option to interview by telephone, Skype, FaceTime, or in-person, depending on the preference and availability of the interviewee. The validity of each interviewing medium was previously discussed in Chapter 3, and was ultimately found to be non-significant to subsequent data collection.

Recall from Chapter 3 that the practical guide for qualitative interviewing outlined by Turner (2010) was consulted. Summarized here, the 'preparation stage of interviewing' consisted of outlining the purpose of the interview to the participant, addressing terms of confidentiality, the general format of the interview was explained, the approximate length of time for the interview was indicated, and a recording device was enabled after the participate confirmed acceptance of recording the interview. During the next phase of 'interview implementation,' occasionally the recording device was checked to ensure proper functioning, one question was asked at a time, the interviewer remained neutral (as strong emotional reactions may bias the interviewee), transitions were provided between major topics, and questions were asked to focus the interview back to the original questions if off-topic digressions occurred.

All interviews were digitally audio recorded then transcribed verbatim by the author as recommended by Merriam (2009). The interview transcripts served as the data for Research Question 3a and analyzed following the procedure for the directed approach to qualitative content analysis (QCA), described next, and coded using MAXQDA software, Version 12 (VERBI Software Consult, 2015).

Directed Approached to Qualitative Content Analysis (QCA)

The **directed approach to QCA**, in which pre-existing codes guide the analysis process (see Chapter 3) is summarized here, and was used for the coding of all interview transcripts of first-year, second-year, and third-year medical students from IUSM-B, IUSM-E, and IUSM-FW and for the open-response questionnaire item. The original codebook of 13 codes created from the pilot study in Chapter 4 (Table 4.1), along with the four emergent codes discovered during that pilot study, resulted in a total of 17 codes used as the initial codes for this present study.

Following the directed approach to QCA procedure (Hsieh and Shannon, 2005; Mayring, 2014), all interview transcripts were read through initially to obtain a holistic sense of the data set. Coding of the interviews began with the initial codebook of 17 codes; however, during the coding and analysis process, the need arose to refine the codebook by condensing similar constructs. This procedure is commonly used in qualitative data coding, especially when predetermined codes are utilized ("Tips and Tools #18: Coding Qualitative Data," n.d.). The revised, collapsed codes were then used for the subsequent rounds of data analysis (Figure 6.1). During the second round of reading through the transcripts, relevant text was assigned one or more of the pre-

established codes from the newly revised codebook. Interesting text was flagged during

the third and fourth rounds of transcript analysis for possible consideration as an

emergent code (defined later in this section).

Figure 6.1: Visual depiction of the codebook revision process and the final codes used
          for the present study of the medical student interview transcripts
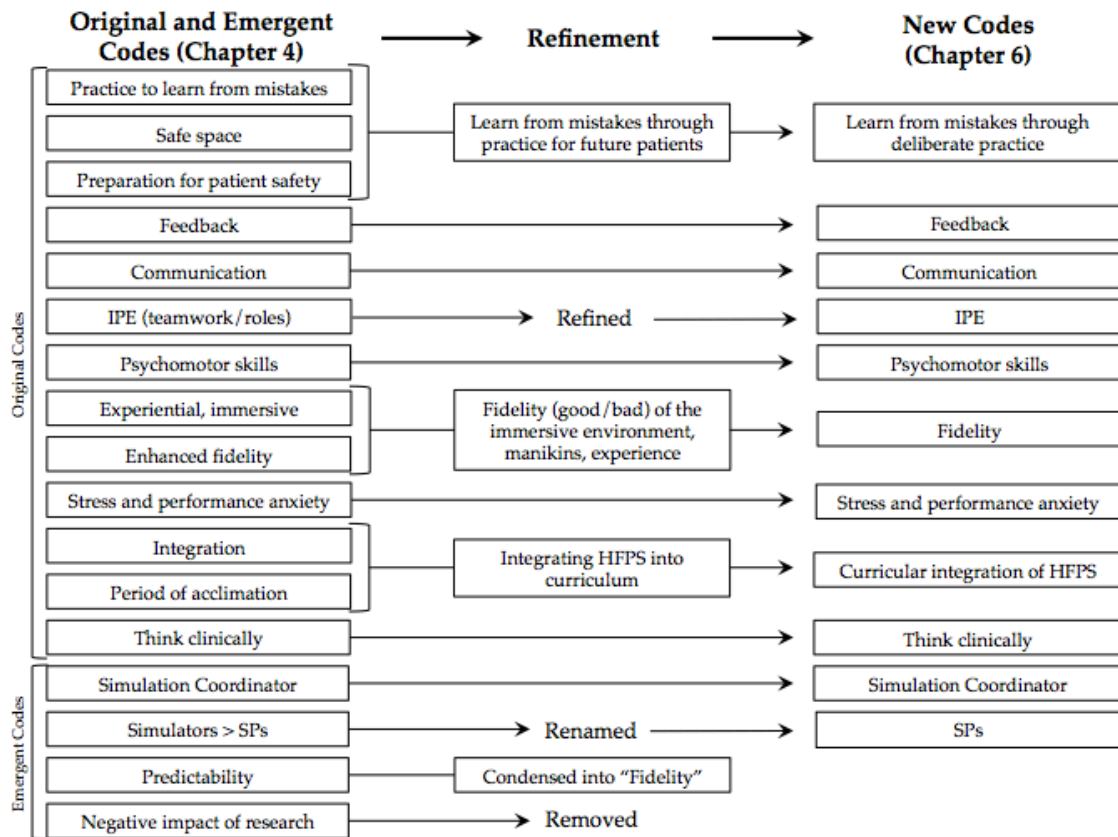
Original codes and emergent codes were derived from the pilot study (see Chapter 4).
The codes were revised and refined and the new codes for the present study are shown in
the right-hand column.

Explanation of the Revised Codebook

        During the pilot study and the initial analysis of this portion of the dissertation,

several codes were found to explain similar constructs and were thus combined (Figure

6.1). First, the codes 'safe space,' 'preparation for improved patient safety,' and 'practice

to learn from mistakes' were combined into one code because they essentially described the same concept: that simulations provide learners with a safe, supportive environment to learn from their mistakes through practice for improved patient safety in their future careers. This effortful practice is a hallmark of 'deliberate practice,' and is explained in Chapter 2. The revised, condensed code was renamed, 'Learn from mistakes through deliberate practice' for subsequent analysis.

Likewise, during the analysis of the pilot study, it was deduced that students need a period of time to acclimate to the simulated environment in order to become accustomed to the simulation sequence, novelty of the technology, and the immersive room to obtain the most educational benefits moving forward. This period of acclimation to the simulation center naturally occurs when HFPS is thoughtfully integrated into the curriculum, and can be seen in this research as first-year medical students are exposed to the IUBIPSC within the first week of their medical training (see Chapter 3). Therefore, the two original codes from the pilot study, 'Integration' and 'Period of acclimation to the simulated environment,' were combined into the single code entitled 'Curricular integration of HFPS.'

Interviews conducted after the pilot study highlighted more aspects of IPE than the original code label of "IPE (teamwork/roles)" conveyed. The current interviews did touch on the dynamics of building a team mentality and learning one's role in the healthcare team, but current interviews also explained the importance of learning and practicing closed-loop communication. **Closed-loop communication** is a method for effective verbal understanding and confirmation by all healthcare team members, and involves three steps: 1. An initial message is verbalized by the sender; 2. The receiver

accepts the message and reiterates the message's information to the sender; 3. The sender verifies the message was interpreted correctly to close the loop of information (Härgestam et al., 2013).

However, more IPE experiences surfaced during these interviews than previously discovered during the pilot study, including negative aspects of timelines and lack of content knowledge on the part of some nursing students that led to poor IPE experiences for some medical students. Thus, the original code was refined to simply "IPE" to capture all of the nuances that this code assumed in the current analysis.

During the pilot study, several second-year medical students reported elements of the simulation center that conveyed an accurate representation of the clinical environment or of the patient manikin. This code represented the authenticity of the simulation center, or 'fidelity,' and was originally named "Enhanced fidelity." However, during subsequent interviews for the present chapter, more medical student perspectives regarding the fidelity of the IUBIPSC surfaced (including the simulated environment, manikins, and overall simulation scenarios). Both positive comments regarding the accuracy of fidelity achieved within the IUBIPSC, as well constructive comments regarding the predictability of simulations and the questionable fidelity depicted in the simulation center for some students, were obtained during the interviews and open-response comments. Therefore, this code was combined with the codes "Experiential, immersive" and "Predictability", and then renamed more generally as "Fidelity," which included comments related to both the positive and negative connotations association with the realism imparted by the IUBIPSC, including the immersive environment, HFPS manikins, and scripted nature of the simulation sequences.

During the pilot study, four emergent codes were identified. As described in Chapter 4, **emergent codes** are identified segments of transcript that do not fit into the previously established codebook and subsequently assigned a new code (Spurgin & Wildemuth, 2016). An emergent code discovered during the process of data analysis from Chapter 4 was originally named 'Preference of simulators over Standardized Patients (SPs),' and represented comments that medical students made after reflecting on their experiences with Standardized Patients (SPs). During the pilot study, some second-year medical students explained receiving contradictory information, inconsistencies, and subjectivity imparted by some SPs; some of these students also explained that it was easier to interact with the patient manikin in HFPS compared to SPs who were obviously acting.

However, during analysis of the current study's interview transcripts, experiences surrounding SPs were found to have much more depth than originally discovered during the pilot study. A complex mixture of opinions regarding SPs was discovered in this analysis, which is described in the results section of this chapter. Given the diversity of opinions regarding SPs, this code was simply renamed "SPs" in order to more accurately capture the range of opinions regarding this instructional adjunct from the pilot study. The 'simulators' portion of the original code was incorporated into Code 6: Fidelity. Additionally, the 'SPs' and 'simulators' code was divided because most of the medical students from the control campuses explained that they valued SPs as the most helpful intervention for learning clinical skills, although many of the interviewees from the control campuses did not have any experience within a HFPS center to compare to their SP experiences. Note that although the focus of this dissertation research was on HFPS, it

is difficult to discuss simulation in medical education without confronting the prominent utilization of SPs for training and assessment.

During the interviews for Research Question 3a, there were no medical students who mentioned the emergent code from the pilot study, 'The negative impact of educational research.' Subsequent interviews with the Simulation Coordinator and physician-faculty members associated with the IUBIPSC confirmed that little research had been conducted over the course of the year. Therefore, this code was removed from succeeding rounds of analysis.

Analysis of the interview transcripts using the directed approach to QCA procedure continued with the revised codebook in order to generate categories and the theme, which are presented in the results section of this chapter. To ensure internal validity through **respondent validation** (also known as member checking or member checks), the specific recorded interview, typed transcript, and preliminary data interpretation from the author was sent via email to each interviewee (21 total) for their review and verification of their intended meaning. The author received seven confirmation emails from interviewees; all respondents agreed that the materials and interpretation of their positions were accurate.

Results

The results of this chapter are divided into five parts: first, general demographic data of the medical students who participated in this study is presented, then the results from the 11 codes from the revised codebook will each be explained; two emergent codes were discovered during the analysis and are described after the original codes; finally the

categories and overall theme are described. This section concludes with the results of the

qualitative supplements to the quantitative findings of the questionnaire data presented in

Chapter 5 (including the Dreyfus ratings, the instructional intervention ranking question,

and the most beneficial aspect of participating in simulation for the intervention group).

General Response Data for Interviews

The "Medical Student Self-Efficacy and Simulation Perception Questionnaire"

(Appendix A) was completed by 34 of the 80 medical students in the IUSM-B

intervention group (Table 6.1). Of the 34 questionnaire participants in the intervention

group, 22 indicated on the last item of the questionnaire that they would be willing to

participate in a brief follow-up interview regarding their simulation and OSCE

experiences. All 22 respondents were contacted via the email that they provided on the

questionnaire between the months of June and July 2017. Medical students were sent a

single email invitation to interview via Skype, FaceTime, telephone, or in-person

depending on their preference and ability. In total, 12 IUSM-B medical students

responded to the email invitation and were interviewed, including: seven first-year

medical students (five in-person, two via telephone), two second-year medical students

(both via telephone), and three third-year medical students (all via telephone).

From the control questionnaires, 17 medical students from IUSM-FW agreed to

an interview and were contacted via the email address that they provided on the

questionnaire. Six responded to the email invitation and were subsequently interviewed

via telephone: two first-year medical students, three second-year medical students, and

one third-year medical student. From the IUSM-E participants, four medical students

indicated that they would be willing for an interview; all were contacted, and three were eventually interviewed via telephone. All of the IUSM-E interviewees were second-year medical students.

A total of 422 minutes of interviews were conducted among the 12 interviews of the intervention (IUSM-B) group and the 9 interviews of the control group (IUSM-FW and IUSM-E); specifically, the elapse time was 260 minutes for the intervention group and 162 minutes for the control group. In the intervention group (IUSM-B), interview times ranged from a minimum of 17 minutes to a maximum of 30 minutes, with average interview times being: 22 minutes for first-year medical students, 20 minutes for second-year medical students, and 21 minutes for third-year medical students. For the control groups, interview times ranged from a minimum of 12 minutes to a maximum of 36 minutes, with an average interview time of 31.5 minutes for first-year medical students, 15 minutes for second-year medical students, and 14 minutes for third-year medical students.

Recall that the semi-structured interviews consisted of predetermined open-ended questions for both the intervention group and the control group (Appendix E). The semi-structured, open-ended nature of the interviews allowed for the organic development of fluid conversation leading to richer data through exploration of additional questions. All interviewees were asked about their perceptions regarding their performance on the OSCE (which was asked as their perceptions of their preparedness for taking the OSCE in Section 2 of the questionnaire) compared to their actual performance on the OSCE, as well as how they typically prepared for the OSCE. Additional questions related to Section 2 of the questionnaire included an elaboration on their choice of ranked teaching

strategies for learning clinical skill (e.g., HFPS, SPs, part-task trainers, real patients, and computer-based modules) and the reasoning for selecting a level on the Dreyfus Model of Skill Acquisition question. All interviewees were also asked about their perceptions regarding SPs that they have worked with in their medical programs (e.g., general perceptions; had they ever received contradictory advice between different SPs or between an SP and their program's recommendations?).

Some questions were group-specific (e.g., medical students within the intervention group were asked about their HFPS experiences in the IUBIPSC, while those in the control group were asked a more broad question related to their perceptions of how clinical skills are taught in their medical program at their particular campus). Medical students in the control group were asked if they ever had a chance to work with nursing students at their campus and if they ever had a chance to practice in a high-fidelity simulation center. The last question for all interviewees asked if they had any recommendations for how clinical skills (and/or HFPS for the IUSM-B medical students) are taught in their program at their campus.

A majority of participants within the intervention group (*N*=30, 78.9%) responded to the open-ended item on the questionnaire regarding their overall impressions of their experience participating in simulations in the IUBIPSC during their medical education. These comments were incorporated with the analysis of the interview transcripts and analyzed using MAXQDA software, Version 12 (VERBI Software Consult, 2015).

Results from the Revised Codes

Code 1: Learning from mistakes through deliberate practice

This code was refined by combining three original codes from Chapter 4 (Figure 6.1): 'Practice to learn from mistakes,' 'Safe space,' and 'Preparation for improved patient safety.' Elements of all three of these original codes in the context of learning medicine through deliberate practice in the simulated environment were observed in the current interviews.

The medical students at the intervention campus (IUSM-B) recognized the basic skills training that they were obtaining within the IUBIPSC and were cognizant of learning while maintaining patient safety using the manikins. These medical students also appreciated the ability to begin practicing clinical skills at an early stage in their medical education through mistakes that would not harm the manikin (MS1-01; MS1-07; MS2-12).

[MS1-01]: "[Simulations] are easily the most helpful tool at our disposal for learning how to manage a patient and building confidence acting as a provider...you feel more confident entering a room…it helps you visualize yourself in that role and I think that helps with confidence."

[MS1-07]: "I think it's good to start out with the manikins because if you make mistakes then you're doing it on a manikin and not a real person."

[MS2-12]: "It's great that we were able to practice clinical skills and take care of this patient [manikin]."

[MS3-02]: "I think it is just extra practice to be in the simulated environment where you know it's okay to make mistakes and you get immediate feedback."

Even though they felt confident in their basic science knowledge, two medical students interviewed from the control campuses (IUSM-E and IUSM-FW) lamented that they did not feel as though they received enough hands-on clinical practice (MS1-01C; MS2-06C). More clinical experience and "doing the real thing" (MS1-01C) in a risk-free setting to develop practical ability was something they explained that they desired more from their medical curriculum. The experiences that they described that they wanted were things that the IUSM-B medical students experienced during HFPS in the IUBIPSC.

[MS1-01C]: "….the best way to learn anything I think is to get into the real hardest, you know, hard and truest thing you can and kind of have to figure it out on your own and then you go back and get feedback."

[MS2-06C]: "…we had all sorts of class time dedicated to you know, going through cases together but it was so different than being in a room with a Standardized Patient and just having that real, real life, comparison, we didn't have that...I feel good in terms of my knowledge, I just don't feel the confidence with applying that knowledge yet…more opportunities for practice like that simulation [center] that Bloomington has I think would be very helpful…I think it would be very beneficial for our knowledge and development of our skills."

The 'safe space' afforded by the simulated environment was also noted by IUSM-B medical students as providing an opportunity for them to practice medicine and obtain valuable feedback about their performance without harming actual patients. IUSM-B medical students explained that they questioned their performance during the simulation (MS1-07), but were appreciative when receiving reassuring advice and positive encouragement during the critique of their performance.

[MS2-12]: "I thought [HFPS] was a great experience because it allowed us to practice and apply our knowledge in a safe setting without fear of making mistakes and causing harm to a real patient. We were able to learn from our mistakes in a risk-free situation."

[MS2-13]: "I mean we're there to learn so if I'm going to do something embarrassing I would rather them call me out on it in that situation."

Code 2: Feedback

The debrief after a simulation event constitutes much of the feedback that students receive from HFPS, which provides students a chance to take a moment to calm themselves and reflect on the rapid, high emotional state experienced during the simulation. The debrief also provides a time for students to discuss their thought processes while in the simulation, obtain valuable advice as to the proper way to handle various situations, and gives students one-on-one time with experienced physician-faculty members to glean professional competence from their years of clinical experience.

Medical students at the intervention campus valued the immediate feedback obtained during the debrief following the simulation (MS3-02), and therefore, they wanted to make the most of the opportunity (MS1-01; MS1-04; MS2-12). They commented on the professionalism (MS1-03) and sincerity of the faculty members when they provided advice (MS1-07), noting both the good things that the students displayed during the simulation as well as offering constructive criticism for improvement in the future (MS1-01) to recalibrate the students' perceived level of current ability (MS1-02).

[MS1-01]: "…[the physician-faculty member] talked about things we've done good and things he liked that he wants us to keep doing and definitely, you kind of missed this…when

[the physician-faculty member] tells you that you missed something, you don't miss it again."

[MS1-04]: "I thought [the debrief] was crucial to the learning experience because I was in there and had the stress of everything going on and I knew I messed up…actually sitting down and taking a deep breath and reviewing everything that I did and kind of talking with an experienced doctor kind of, that cemented everything, knowing what I could do and change going forward, that was critical."

[MS1-07]: "They are very encouraging and if you did something wrong they're just kind of like 'you know, I can see why you thought that but in the future this is kind of the right way to do that,'…I think the debriefing kind of made it, made me realize what was really important out of this sim and things that I can work on, things that I did well. I think the critiques you get afterwards like that's how you grow from the experiences so I think the debriefing is the most important part."

[MS2-12]: "…the way they kind of help us with that feedback, you know they ask us, how well we've done, what we think we could have done differently. Just that positive feedback and learning experience was something that I really valued and enjoyed from doing these simulations. I enjoyed the debriefing, I think that was very vital and an important part of our simulation."

Interprofessional education (IPE) simulations include both medical students and nursing students working together to treat the patient manikin, and these IPE teams receive feedback together during the debrief after they participate in the simulation. Both medical and nursing faculty members are present to critique students on their teamwork and communication skills and point out clinical errors in judgment exhibited by the medical student and nursing student teams. Medical students found this post-IPE simulation debrief helpful (MS1-05; MS1-07; MS2-12).

[MS1-07]:   "…it is like a team effort when you're in there so I guess it is important that we get feedback [together]."

[MS2-12]:   "I think the one thing I did really enjoy about the sims was having that feedback session at the end. I thought that was super helpful just to sit down with the team that I was working with as well as the people who were watching us, because in the moment when we are doing the simulation, it feels so chaotic…so I think to hear feedback and debrief at the end from another perspective is just really helpful."

Additionally, the first-year and third-year medical students in the intervention group noted that having non-graded, formative feedback during the simulations was very important to their learning.

[MS1-04]:   "I also think that having the non-graded simulation was also very important because if I was graded on it, I think I would have been more focused on getting the right answer and, just being, just very caught up in that as opposed to learning which I think a lot of medical students have that personality where it's the grade as opposed to learning sometimes."

However, at times the debrief was less helpful for some medical students due to the anecdotal nature of the semi-structured conversation, lack of specific feedback, and feeling that they did not receive an adequate amount of time during the debrief.

[MS1-02]:   "If [debriefings] could be a little bit longer that would be great. But I know at the same time, we're trying to keep a tight schedule to get all of us to be able to do the simulation. [I would recommend] having ample debriefing time because I think that's the most important part."

[MS2-13]:   "During the debrief sometimes information was given, like, 'oh you should have done x, y, and z' and I couldn't tell if x, y, and z were supported by literature or if they were just the physician's personal preference…having a really

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> tailored, structured debrief feedback session would be
> something to implement."

While a few comments alluded to unconstructive elements of the debriefs, positive comments were overwhelmingly noted in this study. Nine IUSM-B medical students found the debrief to be the most important element of the HFPS experience, which provided an opportunity for them to consciously reflect on their actions and thought-processes, gain a wealth of knowledge from the supervising physician-faculty members, and converse with their nursing student team after IPE simulations. The discourse during the debrief represents a powerful opportunity to elicit metacognitive awareness from students, even when condensed into a short period of time.

Code 3: Communication

Several segments of text were identified during the analysis related to helpfulness of HFPS to acquire communication skills. The medical students described communicating with nursing students in their IPE teams (MS1-02; MS1-07), using closed-loop communication (MS2-12), and audibly discussing thought-processes (MS1-01). The medical students also noted practicing communication skills with the patient manikin (MS1-03; MS2-13; MS3-03). Even first-year medical students acknowledged the reality of the future demands of working as a healthcare team and the importance of communication for efficient patient care.

> [MS1-01]: "…communicating with nurses, working in a team setting
> to manage a patient, that's going to be something we do in
> any specialty, like every day, so the earlier we can get
> started on that, the better, the more confident we are going

to feel going into third-year and the more helpful we are
going to be."

Code 4: Interprofessional education (IPE)

Interprofessional education (IPE), in which medical students and nursing students
collaborate as a healthcare team, build knowledge of their roles and responsibilities, and
practice efficient communication was frequently cited as one of the most beneficial
aspects about participating in HFPS by interviewees within the intervention group.
IUSM-B medical students studied with nursing students prior to participating in IPE
simulations (MS1-04), learned how to work in a real clinical setting as a professional
team (MS1-02), and practiced how to communicate with other healthcare professionals
(MS1-07; MS3-02). Medical students also noted that IPE afforded them a more realistic
opportunity to experience medicine that more accurately approximates what they will
experience daily in a real hospital or clinic setting (MS1-06; MS3-02), encouraged
understanding their roles in a healthcare team (MS1-01; MS3-01), and even those in the
control group explained how important it was to obtain a different perspective from other
healthcare professionals (MS1-02C; MS2-03C).

[MS1-01]: "…[IPE] was good for team building, it was good for them
[the nursing students], it was good for us…that's definitely
something we are not going to get until third year outside
of those IPE sims and learning how to work in that
team…working out our role as a medical student with the
nurses was certainly helpful."

[MS1-03]: "…working with the nurses, I think that was probably the
key thing that I got from the sims...just how to work with
these nurses, the way to ask things, and try to not be in their
way when they are trying to do stuff, but also trying to be
receptive to the patient and the nurses…I really liked
working with the nurses, they were really professional and

they definitely knew their stuff."

[MS1-04]: "I contacted my nursing students beforehand just via text and email and just kind of tried to talk about what we might think would happen. Kind of reassured each other and kind of encouraged each other that we're going to do alright."

[MS1-06]: "This is like the first time where you're getting a chance to work as a team and have the shared mind of what's going on, you actually have the chance to use someone else's brain to solve the problem it doesn't have to be one hundred percent on you…being able to actually talk to someone else in the field and getting to work together on the problem [was beneficial]."

[MS2-12]: "Honestly I feel like the biggest thing that I really got out of the sim was definitely working with my fellow nursing students as a team…you're working with other healthcare professionals, figuring out how to collaborate and talk to each other, and just basically better understanding the dynamics that go on in the future…I think it's super important to develop those relationships and just have a way to communicate and respect other professionals, who have a lot of knowledge and a lot of things to contribute to the team…because I think in a real healthcare setting, that's really what it's going to be about…sims were a great way to get into that habit of, you know, closed-loop communication, and just basically a team collaborative effort."

IPE was viewed as a strong component of the HFPS experience during the pilot study (Chapter 4) and among most IUSM-B medical students in the main dissertation research. However, additional information was obtained and new medical student-nursing student dynamics surfaced during the present study. The importance of preparation, timeliness, and accountability during IPEs, as well as experiencing an overall disconnect with their nursing student teams, left some IUSM-B medical students frustrated and disappointed with their IPE experience.

[MS1-05]:   "The second piece of anxiety is working alongside with the nurses…they were unprepared in my case…one arrived late and unfortunately the other one wasn't prepared in terms of the knowledge."

[MS1-07]:   "My nursing student came in late and so we really didn't get [a pre-brief], so when I walked in I didn't know what any of the stuff was...my nursing student kind of got some bad feedback [during the debrief] and so I felt kind of bad."

In contrast to the HFPS experiences that the IUSM-B medical students had with their nursing student teams, when the interviewees within the control group were asked whether they had opportunities in their medical program to interact with nursing students at their campus, all had indicated that they experienced one to two infrequent "IPE Events." These events were described as medical students, nursing students, and possibly other healthcare professional students (such as social workers or pharmacy students) sitting around a table in a conference room (MS3-01C) or banquet hall (MS2-04C), then discuss and role-play through a patient case study.

Even though these events were sporadic, some medical students still noted the benefits of collaborating with other healthcare professionals at their campus.

[MS1-02C]:   "Their perspective is very different from our perspective. We had a, one of our cases was dealing with parents who didn't want to vaccinate their kids and, I remember when the med students tried to do it, it was all like, throwing facts and figures in their face, and on the social worker's turn, I remember the first thing this young woman said was something along the lines of 'first of all, I can tell the wellbeing of your child is your number one priority and I want to make sure that you realize that's true for me as well' and like jeez that was a good thing that I should have learned how to say, right? Like, talking to people like people, right?"

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[MS2-03C]:   "I found [the IPE Events] to be a worthwhile experience, [other healthcare professional students] offer a much different perspective than what we get and so I find it very useful to get their perspective and to see how they are putting information together versus how we put it together and come to either the same conclusions or different conclusions, so I find it very useful to work with people in other specialties."

Although intended to cultivate a team mentality and acclimate students to their roles working with other healthcare professionals to solve patient problems, some medical students at the control campuses found these experiences to be artificial, the infrequent nature of the events to be unhelpful, and the cases to be irrelevant.

[MS1-01C]:   "…I think there were like one or two [nursing students] at my small group table, but other than that, no, [we didn't do anything] clinically relevant."

[MS2-04C]:   "…as a first-year medical student I didn't know much and the numbers were really off because there were so many nursing people and not many of us and then only a few pharmacy people…I don't think good enough discussion was ever fostered to have people get things out of it."

[MS2-05C]:   "We went to two little conferences with them, other medical professional students, but didn't actually work with them."

Code 5: Psychomotor skills

As in the pilot study (Chapter 4), the interviews for Research Question 3a yielded comments regarding the importance of the physical, psychomotor aspect that HFPS provides. Being able to physically interact with a patient, rather than solely talking with an SP, was beneficial to several first-year medical students with minimal prior exposure to real patient interactions (MS1-01; MS1-03).

[MS1-03]:   "[HFPS] helped me become comfortable doing the more physical aspects of medicine."

Part-task procedural clinical skills training was cited as a major benefit while experiencing simulation. For instance, IUSM-B medical students found simulation beneficial for cardiopulmonary resuscitation (CPR) training (MS3-03), intravenous (IV) cannulation (MS3-01; MS3-02), auscultation (MS3-03), catheter insertion, laparoscopic procedures, and intubation (MS1-02C; MS3-01C).

[MS3-03]:   "I know that there were some heart sounds that I remembered in a real situation just from you know, gathering around Harvey for a couple minutes, that I might not have recognized otherwise."

Code 6: Fidelity

The concept of 'fidelity' is a central aspect of simulation literature, and the fidelity of the IUBIPSC was constantly referred to during the interviews with IUSM-B medical students. Positively coded transcript segments regarding the experiential manikins and immersion within in the realistic environment of the IUBIPSC, as well as a few negatively coded aspects regarding technology limitations and the predictability of the simulation scenarios, were noted in this study.

Although opinions regarding the fidelity achieved within the IUBIPSC (or lack thereof) were broad, all IUSM-B medical students felt the realism of the environment was an important aspect of the HFPS experience. Some medical students commented that the realistic environment was "the same as a hospital room" (MS1-07), and that the patient manikin responding back to them in real-time enabled them to learn realistic patient care

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(MS1-05). Actually being able to physically do things to the patient manikin (MS1-01; MS2-12) as well as learning how to cope with stress and performance anxiety in a real clinical setting (MS1-02) were important aspects of HFPS. Several medical students, from both the intervention and control campuses, claimed that they preferred "hands-on" learning (MS1-05; MS1-06; MS1-07; MS1-01C; MS2-13; MS2-06C); however, only those at the intervention campus had consistent access to the specific form of practical, hands-on learning afforded by HFPS within the IUBIPSC.

[MS1-01]: "[The immersive environment] definitely helps to put you in the right mood and right mindset…then actually doing it, that just kind of cements it…applying it, actually doing it, was really helpful."

[MS1-02]: "…it's always better to have like, a real-life situation…the simulations themselves are always good to feel in that setting…nothing can prepare you more than being in those actual hospital settings and situations and the more realistic it can be, the more prepared you're going to be when you're in the hospital because you'll be familiar with the environment…the last thing you're going to want to be worrying about is your environment, you want to already be comfortable in the environment and being able to focus on the patient and the task at hand versus worrying about where you're at."

[MS1-04]: "…it felt pretty real because you had all the monitors on the wall were the same as a hospital room, you could phone the pharmacy, you could hook up the oxygen that they needed, you could administer drugs through IV…having access to all the different machines and all the technology, that added to it because when I walked in it felt like I was in the room, like it felt like it was real."

[MS2-13]: "…I'm more of like a hands-on, like I learn best by trial by fire, so I preferred the simulation where I did something wrong and then I will never forget it…a huge issue that you know, we're struggling with as we transition from second year to third year is just finding our way around a hospital

room and what we need and where we would find it and
what everything is and what thing goes where."

[MS3-03]:   "…even going into my fourth-year I still feel like that room
mimicked very closely what an actual patient room looks
like and feels like."

Some IUSM-B medical students noted that they took the simulation "seriously"
because of the realistic room, the ability to collaborate with other healthcare professional
students, and the professionalism of the scenarios produced by the physician-faculty and
the Simulation Coordinator (MS1-02; MS1-05). These elements added to the sense of
gravity felt by these students; thus, they claimed that they got more out of their
simulation experience.

However, several questionable aspects regarding the fidelity of HFPS were noted
in this study, such as: mechanical delays in the manikin software (MS3-01C; note that
this particular medical student from the control group experienced simulation outside of
their medical school training); lack of facial and physical characteristics portrayed by the
manikin and the inability to have a "real" conversation with the manikin (MS3-02);
unrealistic pathological presentations, such as "…for cyanosis there was a blue light in
the mouth" (MS1-04); and the inability to meet and get to know the patient (MS1-06;
MS3-01C). The fact that the simulation scenario was "pretend" or "fake" regardless of
the advanced technology or immersive environment was also something that some
medical students struggled to overcome (MS1-01; MS1-02; MS1-07; MS3-01; MS3-03).

[MS2-12]:   "[HFPS] doesn't feel like a real situation because it is, you
know a manikin, and it's just a very structured environment
and it's not like you can stick your head out of the hospital
room and call for additional help…[the manikin] does not
respond like a real person would…they may have heart

sounds and bowel sounds but I feel like the subtleties of a clinical case or a certain condition are just not represented by a manikin alone."

[MS2-13]:   "I think the only time I would have an issue is if the patient was like screaming, it just made me giggle because I knew it was [the Simulation Coordinator] having to scream through the mic."

[MS3-01]:   "I would say because the sim lab is just not real, I mean as much as you want to you know, spend money and try to make it real…I'm not sure how much I gained from doing it on a dummy."

The familiar programmed scenarios of the simulations did present predictable outcomes for some second-year medical students during the pilot study (Chapter 4). Although infrequent, this code was again observed in a few interviews with the medical students for this dissertation research. At least one person from all three classes (first-year, second-year, and third-year) mentioned some predictable aspect of simulation. For instance, one second-year medical student explained that they viewed the simulation as a quick, "10 minutes…you went in and you just needed to zero-in on the patient and the problem" (MS2-13). Another third-year medical student commented on the structured nature of the simulations and performance expectations, "they want you to do the same kind of, what I think is, artificial little things" (MS3-01). Another instance of predictability stemmed from maintaining simulation scenario integrity in a cohesive medical class cohort.

[MS1-03]:   "I know we're such a tight-knit class, sometimes people talk about the sims a little bit and then people who go later on know what to expect."

A unique perspective regarding the predictability of HFPS was obtained from one of the first-year medical students in the intervention group (IUSM-B). This individual mentioned that they had interned at a simulation center as an undergraduate student one summer, thus had "been on the other side" (MS1-06) of the one-way mirror and obtained detailed information as to "the magic of how that works" (MS1-06). This student explained that it was difficult to suspend their disbelief because of their detailed knowledge of how the manikin worked and the predictable scenario sequences did "ruin it a little bit" (MS1-06) for this student.

[MS1-06]:   "…they're always listening for a specific keyword for us to say, so I know it won't progress, they will literally let us stand there not knowing until we say a specific word. So I guess in terms of that predictability, I understand that there's check points and they will essentially just keep us going on a track until we say what we're supposed to say."

During the interviews with medical students from the control campuses, the author described the IUBIPSC, and then asked the interviewees if they felt that they were at a disadvantage compared to the IUSM-B students now that they knew the Bloomington campus had this particular resource, whereas they did not have this resource at their campus. Three medical students answered that they did feel disadvantaged that IUSM-B students had this resource that they did not (MS1-02C; MS2-05C; MS2-06C). Three medical students from the control campuses were unsure if the simulation center would actually have helped them (MS1-01C; MS2-02C; MS2-04C), and two were adamant that they did not mind that the IUSM-B campus had this resource because they valued SPs or time with their preceptors more than participating in HFPS (MS2-01C; MS2-03C). Note that one medical student from the control group was not asked this question, as their

interview was the first one and this question only appeared during the second control campus interview.

While discussing HFPS with the control campus interviewees, one IUSM-FW medical student did admit that their campus had a responsive manikin, however "…its availability is not made explicit" (MS2-02C). Another medical student from IUSM-FW explained that they attended a simulation demonstration while doing research with the Mirro Center for Research and Innovation at Parkview Regional Medical Center in Fort Wayne. While there, this medical student was able to practice on part-task trainers (as described in Code 5: Psychomotor skills) and observe physicians participating in a simulated event. This medical student explained that they enjoyed the practice feeling the manikin's pulses and lining up the EKG on the manikin's chest (MS1-02C); however, this opportunity was not through their IU curriculum and was limited to a one-day experience. This student concluded that, "…maybe the next generation will have more use of this" (MS1-02C).

It is important to note that even with the advanced technology experienced during the HFPS at the IUBIPSC at the intervention campus, and the SPs experienced at both the intervention and control campuses, several medical students commented that nothing will replace working with real patients. Some confessed that the realization of working with a real patient in need of medical care instilled a sense of urgency and a form of metacognition as to their perceived and actual levels of knowledge that could not be replicated with a simulated situation, such as HFPS or SPs (MS1-07; MS1-01C; MS3-01). One medical student commented that working with real patients was important in order to be exposed to a variety of real-world cases and to put a face and personal story to

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the clinical case (MS2-12), while others simply concluded that nothing could fully

replicate reality (MS1-01; MS1-03).

[MS1-07]:   "…until you're in a real life situation you have no idea if
             you're actually good or not. So, I think it's hard sometimes
             perceiving if you are good at something versus not."

[MS1-01C]:   "I think that doing the real thing is always the best
             experience, even if you fumble it up, doing like the real
             thing and having the pressure of the real encounter will
             always, you know, trick your mind into trying to solidify
             the things that you learned."

[MS3-01]:   "I have always felt like simulation prepared me only for
             simulation and has very little application to real practice…I
             don't feel any more comfortable doing it in real life
             because of what I have seen, because you know, poking a
             real person is different than poking a dummy…I prefer real
             patients…nothing prepares you, you know, I get that they
             want us to be prepared to like, be on the ward and do that,
             but nothing prepares you for being on the ward except for
             being on the ward."

[MS3-03]:   "While simulation is excellent and has a whole kind of
             potential, I think that there's always going to be a sense of
             'this is pretend' in a simulation…because it's never quite
             the same, you know, the vein is never as stiff as the rubber
             tube going through the rubber arm…that's not how most
             encounters go in the real world...there's really no substitute
             for the real thing, in the real setting…so I think that to
             advance past a certain point it has to be real patients."

[MS3-01C]:   "…there is no substitute for seeing patients in real life."

Code 7: Stress and performance anxiety

Simulations within the IUBIPSC typically adhered to fast-paced, ten-to-fifteen

minute scenarios followed by a period to reflect on that experience, known as the **debrief**

(see Figure 3.3 for the general sequence of simulations at IUSM-B). This rapid sequence

generated stress and performance anxiety for some IUSM-B medical students as they explained that they "always felt short on time and rushed" (MS2-13). General feelings of nervousness, stage fright, and anxiety while participating in the simulations were mentioned during the interviews (MS1-01; MS1-04). Additionally, the unpredictable nature of the scenarios for some students led to an anxiety-producing mindset. For example, when asked if they had ever found participating in the simulations to be difficult, one first-year medical student explained that the simulations caused, "much more anxiety than an exam…it has to do with the unpredictability of what's going to happen" (MS1-02).

The simulated environment of the IUBIPSC was noted in Code 6: Fidelity, and felt so real to some IUSM-B medical students that they admitted experiencing pressure, anxiety, and stress while participating in their simulations (MS1-03; MS1-04; MS3-01). Because it "gets your adrenaline going" (MS1-07), the realistic, immersive hospital room was cited as a generator of overwhelming feelings as some students felt that they were "thrown into a real-life situation" (MS1-07).

[MS1-07]:   "...it was overwhelming because it was like a real hospital room…when we've been in situations that are a little more, I guess fake with our SPs and stuff, it was kind of a big jump."

The knowledge of being watched from a one-way mirror, and their performance observed for later debriefing, left some students feeling nervous as well. A third-year medical student commented that they were unable to think clearly, "…because we're being watched from the other side of the glass" (MS3-02). However, some IUSM-B medical students thrived in the realistic, high-pressure HFPS setting, explaining that the

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added pressure pushed them into learning to think clearly in the intense situation and

helped them understand gaps in their perceived knowledge, thus aiding in their

metacognition (MS1-03).

[MS1-01]:   "[Being watched is] the worst part of it all, but obviously
              that's a necessary part to get feedback and that's important
              for the whole thing."

[MS3-01]:   "…[HFPS] puts you under pressure like you are in real life,
              you know, because otherwise you think like, I know how to
              do something but you really don't know how to do
              something, so the little bit of pressure is nice."

One thing that did help students calm down during the simulations was

participating in HFPS after they learned about a topic in a block of course material. Some

explained that being familiar with the basic science material helped them to overcome

feelings of nervousness (MS1-05; MS1-06; MS1-07), highlighting the importance of

curricular integration.

Code 8: Curricular integration of HFPS

HFPS has been cited as a way to bridge the gap between basic science knowledge

and relevant clinical application. Integrating simulation as a cumulative unit assessment

promotes the application and transfer of theoretical knowledge to practical contexts.

Several medical students, from both the intervention and control groups in this study,

agreed with this concept, claiming that their basic science studies (e.g., courses in human

anatomy, physiology, microbiology, etc.) should not be relegated to the first two years

while clinical rotations and physician-related skills are taught in the third and fourth

years. Instead of this traditional curricular model, some interviewees explained that

practical clinical skills should be integrated with their basic science coursework throughout the medical curriculum, beginning in the first year (MS1-04; MS1-05; MS1-07; MS3-01C).

[MS3-01C]:   "This whole idea of like teaching you know, basic science for a whole year and not really bringing in any clinical application is really silly to me…a lot of first-year medical students really struggle with feeling overwhelmed, and even like depression and questioning why go into medicine, and I think that the way the current curriculum is set up kind of feeds that because it kind of leaves to the side the whole point of medicine, which is just taking care of patients."

Although the HFPS conducted within the IUBIPSC attempted to integrate coursework with clinical knowledge, effective simulations may require more appropriate scaffolding for novice learners. For instance, several IUSM-B medical students explained that they preferred to learn a block of course material followed by a culminating simulation experience, thus connecting their theoretical knowledge to a practical application. As exemplified by the interviews in the current study, first-year medical students commented that it was often difficult to filter and prioritize information (especially because their simulations were not correlating to their coursework), thus contributing to overwhelming feelings experienced during the simulations (MS1-03; MS1-06; MS1-07). Also, a second-year medical student explained that they would have liked a handout that summarized information about what was important to take away from each simulation (MS2-13), alluding to a disconnect between their course notes and the simulations. Additionally, some students criticized the simulation schedule, which was usually held in the middle of their examination week, making it difficult to prioritize studying for their course examinations and preparing and learning from HFPS.

[MS1-04]:   "Even in the first-year [simulation should be used] as long as it's relevant to what we are learning, not something that we don't know and we have a bunch of background information to gather before we can go in and be successful."

[MS1-07]:   "Our second sim was over asthma which was hard because we haven't talked about asthma much in class so we had to do a lot of outside research and rely on our nurses for help which was stressful."

[MS2-13]:   "[The simulations] were stressful just because they were in the middle of our exam week sometimes, so I think that it was just balancing committing time to preparing for the simulations versus committing time to do an exam that is an actual grade."

When asked during the interviews about the amount of simulations offered during their curriculum, medical students within the three different class cohorts were relatively divided (Table 6.2): five (71.4%) first-year medical students explained that they would prefer more simulation opportunities within their initial year of medical school, whereas two (28.6%) indicated that the amount that they experienced was sufficient; both second-year medical students interviewed claimed that the number of simulations that they participated in was sufficient; while the three third-year medical students were evenly divided with one indicating that they wanted more simulations offered, one said the number was sufficient, and the last third-year medical student said that, "…less would be fine. I think there's a lot of things you can do more efficiently" (MS3-01).

Table 6.2: Frequency distribution, as a percentage, from IUSM medical student
interviews of perceived number of simulations (HFPS) offered

	Preferred more simulations	Amount of simulations offered was adequate	Preferred fewer simulations
MS1	71.4	28.6	–
MS2	–	100	–
MS3	33.3	33.3	33.3

As described in Chapter 3, first-year medical students had limited access to HFPS

in their initial year of school, participating in one Basic Life Support (BLS) simulation in

the fall semester and an IPE asthma simulation in the spring semester. As noted in the

previous paragraph, some first-year medical students stated that they desired more time

within the IUBIPSC practicing the actual art of medicine. Those from the control

campuses also explained that although they had a plethora of lectures, hands-on training

was limited.

[MS1-07]:   "[HFPS] is helpful, but again, we only did it for a day so
            it's hard to get a lot out of something that you are not using
            a lot."

[MS2-06C]: "We had a lot of lectures for our ICM class, our physical
            exam class, and you know, it was a lot of our time taken up
            with that and a lot of actual lecturing, about how to do the
            exam and not as much time you know, doing the exam."

Code 9: Think clinically

The ability to "think clinically" translates to cultivating the mental framework of a

physician by reasoning through a patient case under pressure and developing flexibility in

making quick, yet informed, decisions (Gordon et al., 2001). The dynamic nature of

simulations allowed students more flexibility in their thinking and learning compared to a

traditional classroom setting. Several IUSM-B medical students noted the ability for

HFPS to help them develop the skills to "think quickly on your feet" (MS1-01; MS2-12;

MS3-02), to "handle whatever is coming at you" (MS1-01), to maintain focus in an

unpredictable situation (MS1-02), and cultivate the ability to manage a patient by

obtaining pertinent medical information, integrating that information to make informed

decisions, and thinking about the next step in diagnosis and a treatment plan under

stressful, lifelike circumstances (MS1-04).

[MS1-03]: "It was kind of adventurous, I liked it a lot, I didn't really know what I was going into which was good…it's not like a multiple-choice test were you just pick one."

[MS1-04]: "Being able to compose myself and talking to someone, being able to think while I'm trying to process information…in actual practice you're going to have to think under pressure and time constraints…there's nothing like that taught in the classroom. You can't prepare for those kinds of experiences unless you go through them."

[MS2-12]: "I definitely think that going through the simulations was really helpful in sort of helping me to think on my feet, figure out what to say to patients…just going through that process of treating the patient was really helpful in sort of setting up how to act and behave around the patient…and prepare ourselves for third year and fourth year and so on."

[MS2-13]: "I learned to really tailor my assessment to what's going on in the moment…getting those important facts in the sim-like fashion, I think we learned how to be really efficient with that in the simulation process…I feel a lot more comfortable going into a patient's room and asking them questions."

Participating in HFPS also aided IUSM-B medical students to start developing the

"flow" of their routines as a future physician (MS1-03). This flow was explained as first

introducing themselves to the patient, obtaining the patient's preferred name, and

systematically gathering relevant history and physical information before starting to

generate differential diagnoses and potential treatment options, all while still maintaining

a dialogue with their patient and other healthcare providers.

> [MS1-03]: "…there was a certain flow that I think will be, would translate really well into a real life environment…."
>
> [MS2-13]: "I think [HFPS] influenced my routine, and I do think the whole like closed-loop communication that is really stressed, introducing yourself to the patient and making sure that you have their preferred name, I think those parts I still carry with me…I do think that elements of the routine and making sure that I am getting the information that I need is something I will carry over to a real patient."

Even first-year IUSM-B medical students could see the potential that participating

in HFPS may have on the way that they interact with future patients (MS1-04). During

the interviews, medical students claimed that patients have expectations regarding the

knowledge and skills required of their healthcare providers, and HFPS helped them to

acquire these future patient expectations (MS1-01). Being able to recognize what other

healthcare team members are doing and learning how they, as medical students, can

contribute was another important part of the simulation experience (MS1-01), as well as

cultivating a life-long learning mentality that a physician must have to prepare for the

unpredictable nature of patient care (MS1-05).

> [MS1-01]: "[HFPS] helps you hold yourself better and you kind of exude that confidence, [patients] will respond well to that…it's going to make us better in third-year…the sim center helps you put yourself in a provider role…get in the routine…why wait until half way through med school to really get comfortable doing these things?"

[MS1-02]:   "[HFPS] helped me to know what it should be like in the clinical setting…the goals and expectations of what it would be, which helps when you're in a real situation…this manikin's going to be someone one day."

[MS1-05]:   "…it was important for us to learn the basic science by ourselves so that's what I liked the most. That we were forced to figure it out and not, there wasn't a clear path."

Finally, third-year IUSM-B medical students who were currently in clinical rotations reflected on their HFPS experiences and noted how participating in these simulations translated to their current clinical responsibilities. These third-year medical students provided recommendations to continue implementing HFPS in the medical curriculum as early as possible.

[MS3-02]:   "I think it's helpful to have that experience before you actually have to go into a real patient's room and kind of mess with the machines and things like that."

[MS3-03]:   "I think those sims were incredibly useful for just being a physician in general…I think it was a good idea to get as much clinical experience as early on as possible including sims, just because the transition from classroom to clinical is just amazingly staggering, the types of things you need to learn, the amount of things you need to learn is so large, that any exposure to that before third year really is a good idea I think."

Code 10: Simulation Coordinator

The emergent code regarding the importance of the role of the Simulation Coordinator from the pilot study (Chapter 4) was also prominent during the interviews with first-year, second-year, and third-year IUSM-B medical students for this dissertation research. The Simulation Coordinator was again found to be an integral part in all aspects of the simulation, including providing comprehensive explanations during the pre-brief

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orientation (MS1-03), organizing the overall structure of the simulation event (MS3-02), and enhancing the fidelity of the simulation by contributing to the realism portrayed during the simulation scenario (MS3-01).

IUSM-B medical students viewed the Simulation Coordinator as the conductor of the simulations as well as an educator. The Simulation Coordinator was observed actively instructing students during the pre-brief and throughout the simulation. As one first-year medical student commented, "[the Simulation Coordinator] will kind of guide you if you start to forget something without blatantly telling you what to do" (MS1-01). As an example of enhancing the realism of the simulation, the Simulation Coordination would remind students during the pre-brief to obtain the most out of the scenario as possible, regardless of the technological limitations, "She always said don't ever let what the manikin can do or can't do hold you back from doing what you want, and I appreciated that" (MS2-13).

Realism was also conveyed to students through the Simulation Coordinator's portrayal and embodiment as the manikin patient through a microphone from the control room, "[the Simulation Coordinator] can give a history…she does a good job of vocalizing…so you can get a lot of information that the manikin leaves out" (MS1-01). The Simulation Coordinator was also observed ending every pre-brief always asking the students if they had any questions before beginning the simulation. Finally, IUSM-B medical students recognized the time, effort, and dedication that the Simulation Coordinator and physician-faculty members contributed to creating realistic, high-quality simulation experiences during their medical education (MS1-01; MS2-13; MS3-02; MS3-03).

Code 11: Standardized Patients (SPs)

Medical students in the pilot study (Chapter 4) demonstrated a general negative attitude toward SPs in favor of learning from simulators; however, the present study discovered a range of experiences and opinions regarding SPs. The variety of opinions about SPs may be due to the disproportionate sample sizes, with only 11 interviews conducted during the pilot study and 21 conducted for the present students (with 9 of the 21 interviews with medical students from the control group who had extensive experience with SPs and minimal to no experience with HFPS); thus a greater range of experiences and opinions of SPs surfaced. Medical students in the current study commented that working with SPs was beneficial to overcome the awkwardness of becoming comfortable touching real people during physical examinations and having a conversation during history taking (MS1-01; MS1-02). SPs were also viewed as valuable educators, being knowledgeable of expectations, techniques, and learning outcomes (MS1-06), and SPs most closely approximated what they experience during the OSCE (MS3-02).

[MS1-03]:   "The [SPs], I thought that was really helpful. I found that very high-yield, I learned a lot just on the practice patients and getting a chance to like talk with them."

[MS1-04]:   "The Standardized Patients are also very helpful I thought, just because it's a real person and that you're kind of breaking through the awkwardness of trying to do your physical exam on like an actual person."

[MS1-07]:   "The Standardized Patients, the real actors, that's good just getting experience I think, just like talking to people and feeling comfortable touching patients and doing things like that."

Medical students at the control campuses (IUSM-E and IUSM-FW) described their preparation for the OSCE as primarily role-playing with peers (MS2-04C), watching pre-recorded videos (MS2-02C), and participating in practice sessions with SPs through their campus (MS3-01C). Medical students from the control campuses generally had a more favorable view of SPs, describing SPs as being the "closest thing" to an actual patient (MS1-01C), although almost all students from the control campuses had no experience with HFPS to compare to their SP experiences.

Based on revelations discovered during the pilot study (Chapter 4), all medical students were asked during the interviews if they had ever received contradictory advice from an SP during an encounter. A majority of medical students (62.5%) from both the intervention and control campuses claimed that they had received poor advice from SPs at some point. For example, medical students claimed to receive contradictory advice from the recommendations put forth by their medical program and inconsistent information between different SPs.

[MS1-05]: "Standardized Patients can be iffy because they could give you contradictory information from Standardized Patient to Standardized Patient…a lot of conflicting things. They put their feeling into it and their own personal bias into it."

[MS1-07]: "All of the SPs like different things, they like questions asked in certain ways…so you can get conflicting ideas that way which can be really frustrating."

[MS2-12]: "In terms of real patients, I did honestly enjoy interacting with them but a lot of the real patients that we used and volunteer patients in Bloomington aren't always on the same page with our learning goals and the presentation and sometimes it can be frustrating as a student preparing for the OSCE."

[MS2-01C]: "…you would think that the Standardized Patients would all do it the same way because they're standardized, but that wasn't the case…it was kind of confusing sometimes when comparing notes, like what you were actually supposed to do."

[MS2-04C]: "The Standardized Patients would be nit-picky about random things that we had never heard of, we all got dinged because we didn't listen to their heart when they were sitting up and lying down and on their side and it's just, it was arbitrary, it felt arbitrary and if there was an explanation for it, no one ever gave it to us, so it didn't help."

[MS3-03]: "I do remember some instances where the Standardized Patient would tell me one thing and it would have been different from what we had learned in lecture…I just remember a lot of that information not being similar…the Standardized Patient told us a lot of things that, I don't know, didn't kind of fit."

SPs were also described as more contrived compared to the realistic environment of the simulation center and some students found it difficult to empathize with someone playing a fake patient (MS1-01; MS1-07; MS2-05C) in an inauthentic situation (MS2-06C). At times, some students felt that SPs were unprepared (MS1-02C; MS3-01) or were unfamiliar with how to react to alternative diagnoses that the medical students may suspect (MS3-03). SPs were described as being subjective (MS3-01) and the fidelity conveyed by SPs was described as limited as they had to pretend signs and symptoms, thus demonstrating a discrepancy between the physical examination findings and the portrayed conditions (MS1-01).

[MS1-01]: "It was more just kind of an act [with SPs]…you're just kind of doing this skit almost with this Standardized Patient."

[MS2-02C]: "I found often they either knew too much about what they

expected us to do, that their responses, like they were more likely to give me answers that were, I guess with more medical jargon than I feel like an actual patient might. Or anticipate what we needed to do, which led to sort of an inorganic experience."

[MS2-05C]: "…it's still not the same because if you're supposed to be listening to a patient who has a cough, you know, pneumonia, but you don't hear any signs of consolidation when you do your physical exam, it just makes it more difficult to really glean something from that. And also during the interview, I always just kind of find it a little hard to act like, really empathetic when they are not actually sick, you know?…you just can't connect with someone playing a fake patient as well."

[MS2-06C]: "…when we had a Standardized Patient, it kind of felt more like we were going through the motions, finding the right, you know, trying to say the right things as opposed to adapting to the situation."

[MS3-01]: "[SPs] have different preferences…I feel like they judge you…I have gotten bizarre comments…like personal weird stuff, so I just don't find that to be useful, like that doesn't judge how well I know the material…that is just a personality thing…so the pageantry of the Standardized Patients is what I dislike about it."

Although many students experienced receiving this contradictory advice, one medical student from the control campus (IUSM-FW) found the variety beneficial because, "every patient is different and you have to handle them a little bit differently anyways" (MS1-02C). However, another interesting finding came from the physicality of the SPs. One student commented that most of their SP encounters were homogenized, in which they practiced with similar types of SPs with simplistic, obvious conditions thus limiting their access to patient variety (MS2-12), while another student explained that they were unable to conduct a full examination on their obese SP (MS2-01C).

[MS2-12]:   "…sometimes I find it a little bit unhelpful [working with SPs] because, at least in Bloomington we kind of bring in the same volunteers or they are very, very similar so we don't get to see a huge variety of cases, and they sort of end up with very common or simplistic problems, so when it comes to making the assessment and the plan of our history and physical that can be a little less helpful."

[MS2-01C]:   "We got a Standardized Patient who was easily 500 pounds and I couldn't palpate anything, and I was surprised that they had a patient like that as an SP because I couldn't even do half of the neuro exam because she couldn't walk heel-to-toe."

Recall that medical students from the control campuses generally held a more positive view of SPs than those medical students from the intervention campus (see Table 5.12). While both groups of students made similar comments about how SPs are useful for practicing communication and some physical examination skills, challenging elements associated with the SPs surfaced between both the intervention and control groups. This may be an inherent problem with the IUSM SPs, or it could be a systemic problem when using SPs for medical training. More research is needed to further elucidate the standardization of the SPs and their specific role in medical training.

Emergent Codes

Two additional codes were derived from the interview transcripts of the current study during subsequent rounds of coding that had not previously been identified in the revised codebook. These codes, known as **emergent codes** (Spurgin & Wildemuth, 2016), were entitled 'Bloomington privilege,' and 'Inherent problems with the OSCE.' These emergent codes will now be described in further detail. Note that these codes are

different from the emergent codes found during the pilot study, as those emergent codes were already incorporated into the codebook for this analysis.

Emergent Code 1: Bloomington privilege

      While interviewing the IUSM-B medical students, several instances were coded in which the IUSM-B medical students acknowledged the additional practice and skills that they received within the IUBIPSC and they were cognizant that other IUSM campuses did not possess a simulation center, or perhaps did not utilize it as regularly as they were able to in their medical program. This code was defined as knowledge of the additional opportunity of regularly participating in HFPS, even though a definitive benefit could not be confirmed. All three levels of medical education (first-year through third-year) at IUSM-B are represented in this emergent code. It is interesting to note that even first-year medical students with minimal clinical experience recognized the potential applicability of participating in HFPS to their future careers.

> [MS1-01]: "I think that the sim center is a really good learning tool that we have that a lot of campuses don't have."
>
> [MS1-02]: "…the simulations themselves again, those are very fun and I'm happy to have the opportunity."
>
> [MS1-07]: "It's more than what a lot of other campuses are doing."
>
> [MS2-13]: "I literally treated [the OSCE] exactly like a sim…I think that was the huge benefit coming from Bloomington, I wasn't nervous about the focused history and physical at all…the monitor is exactly what a real hospital monitor is like, so I enjoy that now, knowing where to look for all the numbers…On my first day of surgery orientation, I had to run a code by myself, like a fake code obviously, and I wouldn't have been able to do that if we didn't get so well

trained in Bloomington, you know? I was the only person
in my group that was able to do that."

[MS3-02]: "I think Bloomington has an advantage over some other
campuses."

This code was echoed by the medical students from IUSM-B as exemplified in

the quotes above; however, statements related to this code were also reiterated by those

medical students from the control campuses (both IUSM-E and IUSM-FW). Some

medical students from the control campuses recognized the potential value and utility of

HFPS during the interviews, even though they had little to no exposure with this

instructional intervention. Although acknowledging that it was difficult to hypothesize

the potential disadvantage that the medical students at the control campuses experienced

compared to these students at the intervention campus, some interviewees still expressed

a feeling of unfairness at their inability to experience HFPS during their medical

curriculum.

[MS2-05C]: "I would say that I am at a disadvantage in terms of
timeliness of maybe learning how to handle some of these
situations…I won't have prior knowledge. So they have
that advantage of prior knowledge and a little experience."

[MS2-06C]: "Hearing that other campuses may have things that some
others don't, I think that's definitely something to look into
and kind of compare how they use those resources…if they
are getting Standardized Patient contact and these high-
fidelity simulations, I think there might be some disconnect
there and maybe even the playing field...I feel a little bit
disadvantaged compared to them."

Emergent Code 2: Inherent problems with the OSCE

The Objective Structured Clinical Examination (OSCE) was utilized for the

quantitative portion of this research (Chapter 5), which served as a proxy measure for competent behavior. However, the qualitative interviewing portion of this research discovered systemic problems with the OSCE itself. Half of the medical students interviewed from both the intervention (IUSM-B) and control campuses (IUSM-E and IUSM-FW) found the OSCE to be frustratingly specific (MS1-05; MS1-07; MS2-13; MS2-03C; MS2-04C; MS3-01C), subjective (MS2-02C), desired a clear rubric which they did not receive (MS1-02C), and some felt as though they were not provided adequate preparatory guidance as their instructors did not have a clear grasp of the OSCE requirements (MS1-05; MS1-06; MS2-12; MS2-03C; MS3-02).

[MS2-02C]: "…there are a lot of aspects of the OSCE that I find very subjective and, or there are very specific ways they want you to do things but those, like specific things are not made very explicit, like for example, when you listen to the four quadrants of the abdomen, regardless of when you hear bowel sounds you need to listen in that quadrant for at least 15 seconds, so like, little things like that always make me feel underprepared for the OSCE."

[MS2-03C]: "…it would have been useful for the physician-faculty to know what was expected on the OSCE so they can teach appropriately."

[MS2-05C]: "I don't think everybody was exactly on the same page with what Indianapolis expected from us and they would try to give us some more, real-world advice although, I get it, but it doesn't actually apply to what we have to do to, you know, to get good scores for Indy…so that would be kind of frustrating."

[MS2-06C]: "…having a better idea going into it of what the actual day will look like would have helped tremendously."

[MS3-02]: "I kind of went into it not really knowing what to expect, but, I don't know, I just kind of, I don't know what to say, I kind of winged it."

[MS3-01C]: "Yeah, so that actually was a frustration I think of me, and all my classmates was what was expected in certain situations, you know do I really need to listen to the heart sounds in all four spots and you know, flip the stethoscope over and listen with the diaphragm and the bell both, how many lung sound spots do I need to listen to? It was kind of a mystery to us like what exactly was the expectation as far as grading."

Several interviewees viewed the OSCE as something to "just get through" (MS2-02C), "checking the boxes" (MS1-07), or perceived it as an exam that they needed to do just well enough on to pass (MS3-01), because most found this exam to not reflect what they would actually do in real life practice. Medical students would describe instances where they received practical advice for real clinical encounters from their preceptors or from physician-faculty members, but that advice would not apply to successfully completing the OSCE (MS2-02C; MS2-05C).

[MS1-07]: "Sometimes it's like, when you're in the OSCEs it's just making sure you're checking the boxes, so what they want to see, but it's not always reality."

[MS2-02C]: "I find that in clinic settings what is a full physical exam is not what is necessary for the OSCE."

[MS2-04C]: "…unless you did the physical exam a certain way, then you didn't get all the points, even though the end result was the same, so it, so it kind of became like this stressful thing…even the clinicians that we would be talking to at our preceptors were giving you potentially better alternatives of ways to do the same thing…eventually it become clear that like, as long as you did enough the OSCE would be fine."

[MS3-01]: "You know, my goal with the OSCE is to just get through it and pass because it, the score doesn't have much bearing on anything in the future for us…so I mean if they want to prepare us to do better on OSCE they should just say, you know, once every few weeks head-to-toe physical

everybody here we go, which you know, I don't know how important that is to actual practice or becoming a good doctor but it will help you do better on OSCE."

[MS3-03]: "I think those sims were incredibly useful for just being a physician in general and knowing how to take care of certain problems, but on the OSCE you literally just walk in, talk to somebody, do a very quick physical exam, and then leave. You don't really do a whole lot of management."

Three medical students also related feelings of having an inadequate amount of time to complete the requirements for a passing score on the OSCE.

[MS1-02]: "…the time crunch, I think, is the biggest thing, and like, at Bloomington we didn't ever really practice timing."

[MS1-01C]: "...we only had you know, a set amount of time to take both the history and the physical and yeah, so I kind of ran out of time to get in everything that I wanted to…"

[MS1-02C]: "…you're so rushed trying to get everything through you're not really talking to the patients as people."

While almost all IUSM-B medical students found relevant applicability of participating in HFPS to their actual clinical practice in real life, the majority expressed that HFPS did not prepare them for the OSCE during the interviews (MS1-01; MS1-02; MS1-03; MS1-04; MS1-05; MS1-06; MS2-12; MS3-02; MS3-03). The pragmatic skills and practice learned in the simulations did not translate to the rigid, and at times potentially irrelevant, structure of the OSCE. One medical student did claim that HFPS helped them with the focused history and physical portion of the OSCE by learning how to be time efficient (MS2-13), and another student believed that the simulations taught them how to pick up on and learn similar "artificial things" (MS3-01) required for the

OSCE. However, IUSM-B medical students were almost unanimous in believing that HFPS does not prepare them for the OSCE. Perhaps HFPS could be utilized for OSCE preparation by having an OSCE skills workshop within the IUBIPSC, in which medical students practice the specific tasks and expectations that are required for their specific year's OSCE. Alternatively, the OSCE should be modified to reflect more clinically relevant and practical skills that are practiced during HFPS.

Explanation of Categories and Theme

From the 11 codes of the revised codebook, as well as the two emergent codes discovered during the analysis process, three categories were identified and one overall theme was generated from the three categories (Figure 6.2). Note that the directed approach to QCA is flexible in allowing a code to be incorporated into different categories depending on the context of the coded transcript. For example, Hsieh and Shannon (2005) explained that a researcher may need to separate a code such as "anger" into different subcategories depending on whom the anger was directed toward. Several codes used in the current analysis presented a duality and necessitated this approach, for example Code 6: Fidelity of the HFPS felt real to some medical students while others did not feel that the fidelity of the IUBIPSC accurately portray reality, so interviewee comments related to fidelity were assessed for content and context and separated into different categories.

Figure 6.2: Visual depiction of the three categories and one theme that was developed
from the 11 codes

Codes	**Categories**	**Theme**
1. Learn from mistakes through deliberate practice		
2. Feedback		
3. Communication		HFPS is a valuable
4. IPE		educational
5. Psychomotor skills	1. Learning to think and behave like a physician during HFPS	supplement to clinical
6. Fidelity		instruction that safely
7. Stress & performance anxiety		supports the
8. Curricular integration of HFPS		development of the
9. Think clinically		mentality and
E 1. Bloomington privilege		behaviors required of
		a physician through
2. Feedback		deliberate practice,
3. Communication		feedback, and
4. IPE	2. Value of human interaction in healthcare dynamics during HFPS	interprofessional
6. Fidelity		training in a practical,
10. Simulation Coordinator		if not entirely realistic,
11. SPs		setting
5. Psychomotor skills		
6. Fidelity	3. HFPS inaccurately represents reality	
11. SPs		
E 2. OSCE inherent problems		

The 11 codes were condensed into three categories. Note that several codes are used within the development of different categories. A code can be incorporated into different categories depending on the context of the coded transcript (Hsieh & Shannon, 2005). Several codes used in the current analysis presented a duality of opinions and necessitated this approach. Each code was assessed for the content and the context within the transcript and then separated into different categories.

Category 1: Learning to think and behave like a physician during HFPS

Ten codes were condensed into one category:

Code 1: Learn from mistakes through deliberate practice

Code 2: Feedback

Code 3: Communication

Code 4: IPE

Code 5: Psychomotor skills

Code 6: Fidelity

Code 7: Stress and performance anxiety

Code 8: Curricular integration of HFPS

Code 9: Think clinically

Emergent Code 1: Bloomington privilege

Ten codes essentially described a single category that alluded to physically and mentally embodying a physician when exposed to HFPS. This category encompassed the premise of clinical competence, because one of the goals of HFPS is to impart experience to learners with the mental and behavioral framework of a competent physician, including refining conversational flow, learning the basic routine and expectations, understanding general patient management, and cultivating confidence with a life-long learning mentality. These attributes are important to develop and may not be explicitly taught within the traditional medical school lecture hall, and therefore must be acquired and refined in other arenas, such as in a high-fidelity simulation center.

The deliberate practice obtained by participating in HFPS imparts essential training and an opportunity to learn from one's own mistakes on a manikin in a safe, supportive setting (Code 1). Much of the support provided to students derives from the immediate feedback that they received from the debrief from seasoned physician-faculty observing and critiquing their performance (Code 2); although some students found the debrief to end abruptly (MS1-02) or to be unfocused and "a little rambly" (MS2-13), most found the supportive comments, constructive criticism, and positive reinforcement immensely beneficial for their growth and development as a medical student.

The deliberate practice and feedback coupled with the realistic setting of the IUBIPSC (Code 6), allowed IUSM-B medical students (Emergent Code 1) to consistently (Code 8) learn and reason in an actual real-life, slightly stressful (Code 7) context. The opportunities to participate in IPE simulations (Code 4) allowed medical students to practice thinking and behaving clinically (Code 9) as a team. Although some medical students described negative experiences with their nursing student teams who struggled with timeliness or knowledge, most had productive relationships learning to work together as a multidisciplinary healthcare team by practicing closed-loop communication (Code 3) that accurately approximates what students will experience in their daily clinical interactions. The students participating in simulations could also practice communication with the manikin in the form of history taking and patient education, and were afforded an opportunity to do the "the more physical aspects of medicine" (MS1-03) by "actually doing" (MS1-01) practical psychomotor skills with the manikin (Code 5).

Category 2: Value of human interaction in healthcare dynamics during HFPS

Six codes were collapsed to form category 2:

Code 2: Feedback

Code 3: Communication

Code 4: IPE

Code 6: Fidelity

Code 10: Simulation Coordinator

Code 11: SPs

Six codes were condensed into the second category, which portray the important element that human interaction has while participating in HFPS. Although the fidelity of the IUBIPSC (Code 6) was successful in suspending disbelief for some students, not all were equally as convinced. The typical simulation sequence and limitations in the manikin's ability to fully converse with the students, to portray subtleties of facial and physical characteristics, or when the patient manikin displayed inconsistencies and delays in anatomic or physiologic presentation, led some students to criticize this strategy as overly-structured, "artificial" (MS3-01), and simply "pretend" (MS3-03). However, the lack of humanistic attributes of HFPS was largely reduced with practice using SPs (Code 11). The ability to have an actual conversation with a person (Code 3), perform a more thorough physical examination, and recognize non-verbal body language was described as helpful (MS3-02) and valuable (MS2-12). Medical students could learn from SPs in a way that would otherwise be unacceptable with a real patient, and then obtain immediate

feedback (Code 2) from the SPs on what they accomplished well and how they can improve in a real patient encounter.

The human interactions within the IUBIPSC were most notable when medical students collaborated with nursing students during interprofessional education (IPE) simulations (Code 4). The value of these IPE simulations were expressed by almost all medical students as being the biggest, or key thing, that they got from HFPS (MS1-03; MS2-12). Medical students described learning their role in a dynamic, multidisciplinary healthcare team (MS1-01; MS3-01), which simulated what daily life would be like when they entered the real clinic setting, and they were appreciative for the opportunity to cultivate team skills at such an early stage in their medical careers (MS1-01). While not all IPE relationships were productive (MS1-05; MS1-07), all medical students commented on some aspect of being able to practice essential communication skills such as closed-looped communication and patient handoffs.

Finally, medical students in the intervention group noted that they were able to interact with the Simulation Coordinator (Code 10), who not only artfully orchestrated the simulation behind the scenes, but also acted as an educator; the Simulation Coordinator educated the students during the pre-brief and while acting as the patient through a microphone embedded in the manikin, guiding students through the scenario if they got lost without blatantly telling them what to do (MS1-01). The Simulation Coordinator also fully embodied the simulations, and encouraged the medical students to do the same by not letting the limitations of HFPS hold them back from conducting themselves as capable physicians (MS2-13).

Category 3: HFPS inaccurately represents reality

Four codes were combined to create category 3:

Code 5: Psychomotor skills

Code 6: Fidelity

Code 11: SPs

Emergent Code 2: Inherent problems with the OSCE

In addition to the unrealistic fidelity of the IUBIPSC with regard to the static patient manikin and predictable scenarios (Code 6), the SPs (Code 11) were also criticized at times for being subjective, biased, contradictory, and unknowledgeable about the learning objectives (MS1-05; MS1-07; MS2-12; MS2-01C; MS2-04C; MS3-03). Learning basic clinical psychomotor skills (Code 5) was impacted by both HFPS and the SPs: the manikins were described as containing stiff rubber tubes for blood vessels (MS3-03) and more physical aspects of medicine could not be performed on SPs. Another instance of inaccurate realism derived from the unrealistic expectations of the OSCE (Emergent Code 2). Some medical students viewed this exam as simply an exercise in memorization and adherence to standards that were not made explicit and would not be utilized in their actual clinical practice. Thus, HFPS, SPs, and the OSCE were found to not accurately represent reality at times, leading to several students claiming that nothing can replace working on real patients (MS1-01; MS1-07; MS1-01C; MS2-12; MS3-01; MS3-03; MS3-01C).

Theme

Given the complex dimensions of HFPS in medical education, multiple perspectives were captured in the three-category model presented. Several dual perceptions were discovered, including advantages and challenges of the simulation technology, benefits and drawbacks of the overall simulation sequence, and the strengths and shortcomings of utilizing SPs. Taken together, the **theme** of this qualitative investigation into Research Question 3a, asking "How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?" is: HFPS does impart students with the clinical mental framework and behavioral mannerisms of a practicing physician and thus is an important educational supplement to their clinical training; however, it is only one strategy among many that they experience during their education and is ideal for obtaining specific clinical skills and abilities.

Some learners will always view simulation as an inferior education adjunct regardless of the technological advancements presented, thus future research endeavors must investigate strategies to support all types of learners, as there is obvious value in participating in all of the available strategies, including HFPS. As summarized, the theme of this research is: **HFPS is a valuable educational supplement to clinical instruction that safely supports the development of the mentality and behaviors required of a clinician through deliberate practice, feedback, and interprofessional training in a practical, if not entirely realistic, setting.**

Comparison of QCA Conclusions from the Pilot Study to the Present Study

Recall from the pilot study (Chapter 4), that 13 codes were condensed into four subcategories, the four subcategories were condensed into two main categories, and the two main categories were condensed into one overall theme. The present analysis lead to similar conclusions regarding HFPS in medical education (specifically, that HFPS prepares medical students for future clinical encounters through experience and practice in an environment that is safe to fail in, yet physically realistic), but since the focus of the pilot study was a small subset of second-year medical students and was an exploratory investigation of the HFPS experience in isolation from other complex aspects of the medical curriculum, the pilot study's theme ('When strategically integrated into the medical curriculum, HFPS allows students to experientially gain realistic, practical experience to prepare for future clinical demands') revolved around the experiential learning that students are exposed to during HFPS training and the need for integration of HFPS into the medical curriculum.

However, the present study accounted for other dimensions of the IUSM medical student experience, that the pilot study did not, including the OSCE and the incorporation of control campuses not utilizing HFPS. Elements of the subcategories and main categories from the pilot study are still captured within the categories and theme of the present study, albeit in a slightly less convoluted manner. Category 1 of the present study ('Learning to think and behave like a physician during HFPS') incorporated facets of Subcategory 1 ('Importance of safely gaining experience and developing a structured routine for future practice'), Subcategory 3 ('Realistic environment to suspend disbelief and allow students to physically solve patient problems'), Subcategory 4 ('Context of

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simulation within the medical curriculum'), and Main Category 2 ('HFPS should be integrated into the basic science curriculum and incorporate authentic high-fidelity scenarios') of the pilot study. Category 2 of the present study ('Value of human interaction in healthcare dynamics during HFPS') highlighted the interpersonal aspects of HFPS, which was also found in Subcategory 2 ('Clear, concise communication allows for efficient healthcare teams') and Main Category 1 ('HFPS safely prepares students to think and behave like physicians to contribute to an efficient healthcare team') of the pilot study.

Finally, the present study also captured more nuances of contrasting opinions regarding various codes, which was not elucidated in the pilot study, such as positive and negative aspects of HFPS fidelity, the complex subtleties of SPs, and problems associated with standardized examinations compared to practical clinical experience. Category 3 of the present study ('HFPS inaccurately represents reality') was not articulated during the pilot study, was likely discovered by broadening the scope of the investigation, and thus represents a novel finding from the results of Chapter 4.

Qualitative Supplement to the Quantitative Findings in Chapter 5

Before concluding the medical student analysis, several quantitative results found in Chapter 5 were more thoroughly investigated through a qualitative lens during the interviews to provide more context for the conclusions drawn in the previous chapter. The qualitative supplements presented here include: the Dreyfus ratings, the ranking question of instructional interventions, and the most beneficial aspect about participating in simulation.

Dreyfus Model of Skill Acquisition Ratings

As discussed in Chapter 5, some medical students struggled to discern the Dreyfus Model of Skill Acquisition ranking question on the questionnaire, a fact that was discovered only during the interviews. This problem undoubtedly impacted their choices, and thus the overall distribution of ratings. The results of this particular portion of the questionnaire are then confounded and should be interpreted cautiously. Participants explained that they misunderstood the question or the level qualifiers, and issues surrounding the current interpretations of the Dreyfus scale found in the literature were discovered.

Recall that the modified Dreyfus Model of Skill Acquisition includes the following stages: novice, advanced beginner, competent, proficient, expert, and master. The novice stage is described as a first-year medical student at the beginning stage of their education; advanced beginner is considered a junior medical student; a medical resident is labeled competent as they can set up patient plans; the proficient stage is associated with a specialist doctor; and the expert stage is considered a mid-career physician (Batalden et al., 2002). Note that the authors did not identify the master stage in the development of a physician. These medical designations were not presented in the questionnaire; rather, descriptive definitions derived from Park (2015) were included to help guide students in their self-selection (see Figure 3.4).

Some medical students accurately identified the level given their current experience. For example, a first-year medical student indicated that they were at the 'novice' level because they could gather information, but were unsure how to use and apply that information yet (MS1-04). Another first-year medical student also selected

'novice' because, "…sometimes filtering and prioritizing is difficult because you just don't know in real life what's actually important" (MS1-07). An interesting anomaly was discovered as one first-year medical student indicated that they were at the 'advanced beginner' stage; however, this individual had EMT experience prior to entering medical school (MS1-02C). Therefore, although this individual was a first-year medical student, 'advanced beginner' may be appropriate for this medical student given their past experience. This inconsistency in skills acquisition and level of education is not accounted for in current interpretations of the Dreyfus model.

Additional discrepancies arose in the interpretation of the scale and question by some medical students. A third-year medical student had selected 'proficient' simply because they felt "confident" (MS3-01C). Another student answered unrealistically because they did not read the question thoroughly, which asked for their <u>overall</u> ability as a clinician at this time in their medical career; this second-year medical student selected 'expert' while thinking only of the history and physical examination because, "…doing a history and physical was like second nature" to them (MS2-01C).

Thus, information gleaned from this qualitative investigation indicated that the Dreyfus ranking question used in this research needs revision. It was clear from the small pilot study of the questionnaire that medical students required the Dreyfus ratings to have more context and qualifiers to clearly differentiate between the scale levels. However, these qualifiers (adapted from Park, 2015) may have been too specific or lacked enough context to be interpreted properly. As with all investigations of self-reported measures, perception and actual ability may be misaligned, which could have influenced the choice of level by these medical students (see Chapter 5 for a description of the "unskilled and

unaware effect," commonly referred to as the "Dunning-Kruger effect" that explains this phenomenon). While the results of this Dreyfus question are confounded, it was self-limiting in that it only represented a single item and was unrelated to other sections of the questionnaire.

Ranking Question of Instructional Strategies

The questionnaire contained a ranking question (Appendix A and Appendix B, Section 2), which asked respondents to rank five different teaching strategies based on their perception of the helpfulness of the strategy for learning clinical skills. Recall from Chapter 3 that the instructional strategies included: HFPS, SP, real patients, part-task trainers, and computer-based modules. Interviewees were asked to elaborate on their choice of ranked instructional strategy to further extend and explain the quantitative findings reported in Chapter 5.

The instructional strategy with the highest weighted mean for all medical class cohorts was "real patients," except for the first-year medical students within the intervention group, who most frequently selected SPs. This finding was a surprising discovery considering the question explicitly asked the students what strategy they preferred for <u>learning</u> clinical skills, and one would assume that initially learning on real patients would not be preferred. However, the interview data revealed that while working with real patients, some medical students took the situation seriously due to the sense of urgency and realization from the legitimate case, found it easy to sympathize with real patients, and directly saw the relevancy to their future practice since they will be working on real patients in the real world, not on manikins or SPs.

[MS2-05C]: "Ok, so obviously the real patients you can actually hear and elicit the true physical findings and it's just easier to be real with them."

[MS3-01]: "Obviously real patients are the best because that's what we're going to do, that's what we see every day and those are real situations with real human beings."

[MS3-03]: "I really think that real patients is probably indisputably in my mind, the most useful thing."

However, after real patients, HFPS and SPs were relatively evenly split among the average of second choice, with the intervention campus ranking HFPS higher than SPs.

[MS1-02]: "So Standardized Patients I definitely put as number one because that like really puts you in a scenario and often times you forget that they're actors and…then you can go through it and you have a chance to talk with them after and they know what to look for."

[MS1-05]: "For learning, I would rather not learn on a real patient to begin with…I'm the type of person that doesn't like to go in blindly and I feel like, let's try to make this as close as possible to the real thing at least you know, in a uniform way like of how ideally we should approach things, so that's what I like about [HFPS]."

[MS1-06]: "Clearly the Standardized Patients are the best because they can, they know what we're supposed to do…they are essentially teaching with us…here's how you should be touching me, here's what you should be saying to me."

[MS2-13]: "I think for me the simulations were the most helpful because it was just me in the room and I had to put on my big girl pants and do what I needed to do and order the testing and that sort of thing. Ordering testing, diagnostics, treatment, that's something I didn't ever get with Standardized Patients or real patients. I never got those privileges, so that's why I put that as one."

[MS2-03C]: "I mean so I had a lot of experience with Standardized Patients, and based on the fact that they knew both how to act as a patient and what was expected of the OSCE, I found them to be very helpful."

Computer-based modules was mathematically ranked as the least beneficial

instructional intervention as presented in Chapter 5, with most students claiming it only

presented basic material (MS1-03), has little experiential aspects (MS1-01; MS1-06;

MS2-04C), and was "least like real life" (MS3-02) so "you take it less serious" (MS1-

05). However, computer-based modules were a popular option for some students. For

instance, one IUSM-FW student commented that computer-based modules were effective

due to the self-guided nature of the exercises, which encouraged independent learning,

and the modules could be accessed at any time from any location through the Internet.

> [MS2-01C]: "[I preferred computer-based modules] because you can go at your own pace and learn independently, sort of stop and think, ponder more the things that you struggle with or need to think about a little bit more and not waste time on the things that you're comfortable with."

It is important to note that some students commented that ranking the various

instructional methods was difficult as they saw the applicability of each for serving

different learning objectives. For instance, although SPs were sometimes viewed as

inauthentic and low fidelity, some commented that they were an excellent resource for

learning physical examination techniques, information gathering, and building good

patient rapport that was inaccessible with the patient manikin (MS1-01; MS1-04; MS2-

12; MS3-02). However, medical students also acknowledged that administering

medications, oxygen, or completing assessment of all vital signs was impossible with a

Standardized Patient, thus HFPS was more helpful for learning critical, emergency care.

> [MS1-01]: "I mean, I think that they are both important for different things. The SP is definitely good for practicing the H&P because you need somebody who can answer your

questions, and you know, the microphone coming out of the person's mouth is just not as good in the manikin you know, and for the physical skills…it's nice to kind of get comfortable doing that on a real person. But then when you're talking about, you know, codes, when you're talking about asthmas, and all that good stuff, the manikin's cool because you can actually really do stuff to the patient."

[MS1-04]:   "The Standardized Patients are also very helpful because it's a real person and you're kind of breaking through the awkwardness of trying to do a physical exam on an actual person."

[MS3-02]:   "Well it was kind of hard to rank them kind of one to five, I would say different things are helpful for different skills."

Most Beneficial Aspect of Participating in Simulation

IUSM-B medical students were asked to elaborate on their choice of the single most beneficial aspect about participating in simulations at the IUBIPSC during the interviews to supplement the frequency distribution (see Figure 5.8). From the frequency distribution, the most beneficial aspect of participating in simulations for first-year and second-year medical students was 'Integrate basic science knowledge with clinical practice,' while third-year medical students found 'Working with nursing students during IPEs' to be most beneficial. However, several additional benefits not listed on the questionnaire were collected during the interviews.

IUSM-B medical students claimed that obtaining procedural psychomotor tasks and skills, such as inserting IV lines and learning the components of medical kits was beneficial (MS3-01), while others explained that the ability for the manikin to assume various pathologies to expose them to common patient conditions that are ubiquitous across every medical specialty was helpful (MS1-04; MS3-03).

[MS1-04]:   "I think overall, the most beneficial thing would be that you can experience a wide variety of cases and that the simulation center, they can set up any kind of scenario. Without having to find someone with a certain case."

Communication was a common code assigned to the most valuable quality of the simulation experience. How to communicate and empathize with patients (MS1-05) as well as conversing with the patient manikin while obtaining a medical history was important to practice within the IUBIPSC for some students.

[MS3-03]:   "I think the next best thing, if you don't have a real patient, would be a high-quality sim, because you can do quite a lot with the sim man or a good sim manikin with a good sort of simulation outline behind it that you're able to walk students through…the number one thing I got out of the sims was sort of the ability to, to do management while talking with the patient and getting information."

IPE was also cited as the most important aspect of HFPS for learning how to communicate and learning the roles that healthcare professionals assume in the dynamics of an interdisciplinary healthcare team (MS1-01; MS1-03; MS1-06; MS2-12; MS3-01).

[MS1-06]:   "I think working with the nursing students is probably the most beneficial just because that's what our general lives are going to be like."

Medical students also claimed that the most important component of the simulation experience was obtaining feedback (MS1-07), which is consistent with much of the literature surrounding HFPS and was captured in Code 2: Feedback.

[MS1-02]:   "I think it's really good to get feedback on how we are doing because I think that like, we can practice all day long, but unless you are told…there's no way to really

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know exactly how you did and then you can't really better yourself or learn from them…so, it's always good to get feedback to know how to like, better your clinical skills."

[MS1-07]: "I think the critiques you get afterwards like that's how you grow from the experiences so I think the debriefing is the most important part."

Through all of these benefits of participating in HFPS, some constructive criticism and recommendations for how future simulations are conducted within the IUBIPSC did surface. Comments regarding extending the length of the simulated events, having the faculty provide a brief synopsis of salient points to take away from the simulations, and expanding the construction of the simulation center to include different rooms were mentioned.

[MS2-13]: "I understand they have to get a lot of people in and a lot of people out, but I wanted to like follow the patient and a lot of times…I never actually got to treat the patient or I never got to educate them or talk to them about what they have and why I did what I did…I do wish our sim center in Bloomington was at least a little bit bigger or had some more rooms set-up or options like, if we had an emergency department room and we had in-patient room or something like that, just a little bit of variety…I think it would be really cool if after the simulation that we receive some sort of handout or educational component for all the sims, even the one that you didn't get selected for…I think that would be really valuable. And that would be something, a little handout, that I would actually come back to as a third year or a fourth year."

These qualitative summaries add to the quantitative frequencies of the most beneficial aspect of participating in HFPS within the IUBIPSC. Recall from the frequencies that first-year and second-year medical students generally viewed 'Integrate basic science knowledge with clinical practice,' as the most beneficial aspect of

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participating in simulations, while third-year medical students found 'Working with nursing students during IPEs' to be most beneficial aspect of participating in simulations. The qualitative interviewing discovered that medical students struggled to discern a single most beneficial aspect as they found several facets of the HFPS experience to impart them with benefits.

Discussion

The present study used qualitative methods to answer Research Question 3a asking, "How do first-year, second-year, and third-year medical students perceive the utility of, and satisfaction with, HFPS experienced during their medical education?" Twelve interview transcripts from the intervention group, nine interview transcripts from the control group, as well as open-response comments from the questionnaire were analyzed using the directed approach to QCA, and ultimately generated three categories and one overall theme. Some results of this study conformed to current literature surrounding HFPS in healthcare education; however, notable contrasts of this work to published studies did manifest.

Fidelity encompassed several aspects in this research, was incorporated into all three categories, and included the HFPS environment, the manikins, and the clinical scenarios. The realistic environment was a critical element for most of the IUSM-B medical students interviewed and is a fundamental aspect of Experiential Learning Theory (ELT). This theory posits that knowledge is constructed through concrete experience followed by a period of reflection (Kolb & Kolb, 2005). The immersive, realistic world of the IUBIPSC provided IUSM-B medical students with concrete

experiences, engaging them in authentic, experiential practice that was followed by a

period to engage in reflective practice that occurred during the debrief (Anderson et al.,

2008; Dornan et al., 2009; Morgan et al., 2016). The IUSM-B medical students were free

to focus on the necessary tasks for proper patient care, without devoting cognitive

capacity to imagine or mentally construct the environment. Some students commented

that even becoming familiar with the room, equipment, monitors, and basic procedures

during HFPS was invaluable for gaining knowledge in preparation for clinical rotations.

Quraishi et al. (2011) stated many beneficial reasons to engage in HFPS, including the

safe environment to practice and learn from mistakes and the ability to be exposed to a

wide variety of patient cases, but claimed, "the most important advantage of high-fidelity

simulation is rooted in the experiential learning that it fosters" (p. 533).

When immersed in the realistic environment and physically interacting with

elements of the IUBIPSC, some medical students in the present study discovered whether

they could actually think and perform in a lifelike context; the IUBIPSC provided a

medium to encourage metacognition in these medical students (Burke & Mancuso, 2012).

An example from nursing education highlights this point. When 176 junior nursing

students were subjected to an integrated HFPS and problem-based learning (PBL)

scenario of a patient with increased intracranial pressure, students demonstrated

statistically significant improvement in metacognitive ability as measured by a pre-test, a

post-test, and a reliable and valid 15-item tool measuring three domains of

metacognition: cognitive strategy, planning, and self-checking (Lee, Nam, & Kim, 2017).

Continued practice using HFPS will likely aid in enhancing further metacognitive

awareness in medical students as they progress through their programs and into residency training and should be an area of active research for future studies.

The authentic environment and high-fidelity manikins may elicit stress and anxiety among students (Baxter et al., 2009; Harvey, Nathens, Bandiera, & LeBlanc, 2010; Landeen et al., 2015). It is interesting to note that the majority of responses filed under Code 7: Stress and performance anxiety were assigned primarily to excerpts from first-year IUSM-B medical students (specifically, five first-year medical students in this study mentioned stressful aspects of HFPS compared to one second-year medical student and one third-year medical student). This finding may offer additional evidence for the need to integrate HFPS within the medical curriculum (Code 8) and provide a period of acclimation to the simulated environment (Baxter et al., 2009; Dotger et al., 2010), to help bridge the gap between the classroom and the clinic (Brauer & Ferguson, 2014; Eisenstein et al., 2014; Finnerty et al., 2010). Although stress and anxiety are typically attributed to negative emotions, this research found that several IUSM-B medical students actually appreciated the stress induced by the realism of HFPS, viewing it as preparation for the future demands of their medical practice. Research as to the optimal levels of stress for peak performance compared to levels that hinder cognitive ability is ongoing (Harvey et al., 2010; Phitayakorn et al., 2015), and more studies should be done in the realm of HFPS regarding this issue.

Integration of HFPS into the medical curriculum may be necessary for initial acclimation; however, repeated exposure to the same HFPS environment, sequence, or scenarios may lead to feelings of predictability. Captured in the third category labeled 'Inaccurate reality representation,' the segments of interview coded as 'Predictability'

(which was condensed into Code 6: Fidelity for the present analysis) were mainly from second-year and third-year IUSM-B medical students. This finding may indicate that some medical students became conditioned to the prescribed nature of the simulations that are typically encountered within the IUBIPSC, which is consistent with the literature. Simulators have been described as "predictable" (Issenberg et al., 1999), and students know how the scenarios will proceed (Ha, 2016). Therefore, more variety may be necessary in future simulations, particularly for second-year and third-year medical students who likely grow accustomed to the HFPS experience; this is taken into account in the proposed medical curriculum that strategically incorporates HFPS in medical education, found in Chapter 8.

Another instance of predictability that surfaced in this study related to the roles that medical students assume during HFPS. In a study comparing computer-based instruction to HFPS when learning about physiologic shock among 38 second-year medical students, researchers found that some student survey responses indicated a desire to control the simulation engine themselves under supervision (Cendan & Johnson, 2011). Based on the research findings of the present study, an argument could be made that in order to maintain the realism of the simulation, or psychological fidelity, learning too much of the "behind the scenes" aspects of simulation may inhibit the believability of simulation and create a barrier to suspending disbelief. This finding was exemplified by one first-year medical student (MS1-06) in this study who interned in a simulation center and found it difficult to participate in simulations in the IUBIPSC knowing how the manikin functioned, acknowledging the typical dialogue that should be audibly spoken to

progress through simulation sequence, and understanding how the Simulation Coordinator was controlling the scenario.

The need for competent simulation faculty and staff became evident during this research as the Simulation Coordinator was found to be an integral component of enhancing the fidelity for students. Dornan and colleagues (2007) explained that, "an effective workplace teacher is someone who can simultaneously support students and challenge them in a way that builds practical competence and a positive state of mind" (p. 88). The Simulation Coordinator took on the role of embodying the patient manikin, controlling how and when the students noticed anatomic and physiologic signs and symptoms of the manikin, and was observed actively educating medical students and nursing students as they progressed through the simulation. The importance of the simulation operator for delivering high-quality simulation experiences, as well as currently available simulation training and certification, is explored further in Chapter 8.

HFPS also provides a medium for different healthcare professional students to collaborate before advancing to a real healthcare environment (which was captured in Category 2: Value of human interaction in healthcare dynamics during HFPS). IPE simulations allow students to learn how to communicate with other healthcare providers as well as with their patient. Within the IUBIPSC, IUSM-B medical students and nursing students practiced communicating in various forms, such as: closed-loop communication as a healthcare team, audible diagnosis and treatment consideration, and communicating with patients and providing patient education (Feather et al., 2016; Reising et al., 2011). IPE simulations not only permitted students to practice the art of communication, but also

taught students a valuable lesson in respecting the knowledge and contributions that all members of the healthcare team provide for superior patient care.

While the vast majority of IUSM-B medical students described positive IPE team interactions, including preparing for simulations as a healthcare team, demonstrating camaraderie during the stressful simulated environment, and cultivating a shared sense of personal responsibility caring for the patient manikin, a few negative IPE team interactions arose. Some IUSM-B medical students struggled with their IPE teams, experiencing frustration at the lack of promptness, lack of knowledge about the patient case, or incomplete patient handoff technique from some nursing students. Although the reverse may also be true (i.e., that nursing students were frustrated with some of the medical students in their IPE teams), the answer to this question goes beyond the scope of the present research. Future studies should survey both medical students and nursing students to gain a holistic understanding of the complex IPE dynamics that surface while participating in HFPS. The diverse perceptions of interactions between IPE teams, from positive interactions to negative encounters, are consistent with previous reports in the literature (Feather et al., 2016; Herrmann, Woermann, & Schlegel, 2015; McBride & Drake, 2015; Niekrash, Copes, & Gonzalez, 2015; Reising et al., 2011; van Schaik, Plant, Diane, Tsang, & O'Sullivan, 2011; Wong, Gang, Szyld, & Mahoney, 2016), and indicate an important avenue for future investigations, which is discussed in Chapter 8.

Medical students at the control campuses were not afforded many IPE opportunities, and described their infrequent "IPE Events," which were sporadic and inauthentic. The students explained that the IPE Events consisted of sitting around a table with a few other healthcare professional students to discuss a paper-based clinical case,

which is in stark contrast to the dynamic and interactive IPE collaboration that IUSM-B medical students experienced during HFPS. Literature comparing IPE interventions to other modalities, such as traditional instruction, is sparse, which may be due to ethical concerns of exposing students to different interventions when conducting education research (Amin & Abdulghani, 2015). Of the studies found that do compare IPE to other interventions, results are inconclusive.

A systemic review assessed the effectiveness of IPE interventions compared to interventions in which healthcare professionals learn separately or compared to no educational intervention; authors found only six studies that reported objective measures using rigorous approaches such as randomized controlled trials, controlled before and after studies, or interrupted time series studies (Reeves et al., 2008). They concluded that while the studies did report that IPE produced positive outcomes such as collaborative team behavior, reduced clinical error rates, and enhanced patient satisfaction, the small number of studies, heterogeneity of interventions, and methodological limitations prevented adequate generalizable conclusions regarding IPE effectiveness. In an updated version of the same systematic review, the authors found nine additional studies to include (Reeves, Perrier, Goldman, Freeth, & Zwarenstein, 2013). However, the authors again determined that the results were inconclusive due to sample sizes, heterogeneity of interventions, and outcome measures. The authors did provide advice to improve the quality of IPE studies, including: assessing IPE interventions compared to separate, profession-specific interventions; conducting more rigorous IPE quantitative studies supported with qualitative data; and conducting cost-benefit analyses.

A dissertation was conducted at Gardner-Webb University School of Nursing that studied IPE effects on SBAR performance (Pfaff, 2014). Recall that SBAR is a first-letter mnemonic that stands for situation, background, assessment, and recommendation and is used as a structured communication model to efficiently convey pertinent patient information during a handoff from one healthcare professional to another. Pfaff investigated 44 senior nursing students who were randomized to either traditional HFPS or an IPE HFPS that included surgical resident physicians. Using a comparative pretest-posttest study design, the author found statistically significant differences in skilled communication knowledge in the IPE group, concluding that the study provided evidence that IPE enhances team communication skills in a simulated setting.

Given the results of these IPE studies, the foundational experiences of meaningful collaboration as a healthcare team within a simulated environment were not observed among students at the control campuses in the present study. The lack of early exposure to IPE may have an impact on initial team development and communication skills during later clinical rotations. The effect, if any, that a lack of HFPS training with nursing students may potentially have on these medical students is certainly an important aspect to investigate in future, longitudinal studies.

Coombs and colleagues (2017) noted that although HFPS is a widely used pedagogy, it is rarely used within basic science courses, and instead Standardized Patients (SPs) are the most commonly used simulators in the preclinical years. This is likely due to the prohibitive cost of implementing HFPS as well as time required to efficiently integrate this modality into existing curricula. SPs were utilized for the development of communication skills in medical students from the intervention and control groups in this

dissertation study. Both student populations noted that SPs were very effective for practicing their dialogue, interacting with patients, and for performing some physical examinations, which is consistent with published literature. For instance, 154 third-year pharmacy students preferred SPs to HFPS for cardiac and pulmonary assessments based on survey data (Grice, Wenger, Brooks, & Berry, 2013), and trauma teams in five Norwegian hospitals preferred SPs when training for interacting as a team with a patient (Wisborg, Brattebo, Brinchmann-Hansen, & Hansen, 2009). Another study reported that 44 nursing students preferred SPs due to the lack of realism from the HFPS manikin, even though the students performed significantly better on focused respiratory assessments with HFPS (Luctkar-Flude, Wilson-Keates, & Larocque, 2011).

However, negative aspects of training with SPs did surface in this research (and were captured in the third category, 'Inaccurate reality representation'). There were instances of SPs exhibiting bias and the authenticity of SPs was called into question, which may have a less profound impression on medical students than working with real patients (Bokken et al., 2010; Collins & Harden, 1998). Additionally, the fidelity of performing some procedures or maneuvers is limited while using SPs (Wisborg et al., 2009), and the reliability of SPs to provide consistent instruction is an on-going challenge (Dotger et al., 2010).

To investigate this issue and provide more informed consensus regarding the training of SPs employed by IUSM, the Standardized Patient Educator from Indiana University Health was contacted. This individual explained that IU employs eight part-time and 50 supplemental SPs; however, there is some variation in SP use across all IUSM campuses because some campuses utilize their own SP pool, while others use the

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Indianapolis SPs (K. Schroedle, personal communication, November 28, 2017).

Recruitment of IUSM SPs is typically done through word-of-mouth among various

Indiana theater companies, retired nurses, teachers, and other healthcare employees. The

SP Educator explained that SPs undergo the same screening that all IU Health employees

are subjected to, including a mental health assessment, background check, and drug

screening; however, there are no physical restrictions, such as weight or pre-existing

health conditions. The lack of physical restrictions was noted by one second-year medical

student during the interviews, as they found it difficult to perform a complete physical

examination on their obese SP (MS2-01C).

The SP Educator was surprised to hear that some medical students claimed that

the SPs were biased in their assessments and unknowledgeable as to specific learning

objectives or patient presentations. The SP Educator explained that all SPs received, "a

day of training for each event and inter-rater reliability checks (meaning if one SP is in an

encounter, another may be watching and evaluating the same encounter. The SP in the

room must match the SP viewing the encounter)" (K. Schroedle, personal

communication, November 28, 2017). SPs were also given several resources and

guidelines to follow, including: check-lists, learning objectives provided by the IUSM

faculty, and step-by-step procedures. SPs are also required to undergo continuing

education and are instructed to provide formative feedback and to limit subjectivity.

The issues listed above regarding SPs are not unique to Indiana University. Few

studies have specifically evaluated SPs as a practical educational tool; rather, the majority

of SP studies focus on the training and development of the actors (Steinman, 2014).

Additionally, SP investigations are challenging because each SP training program is

highly contextualized depending on the amount and type of program resources available (Nestel et al., 2011). A case study design of four SP programs in different countries (including Australia, Canada, Switzerland, and the United Kingdom) reported several challenges common to all of the programs, including systematic quality assurance and inconsistencies (Nestel et al., 2011). Since SPs are actors, each will have their own unique personality and characteristics that may affect how they interpret questions and formulate responses during interactions with healthcare providers (Steinman, 2014).

The OSCE was also discovered to not meet the expectations of real clinical practice in this study. Although "objective" is in the name of the OSCE and the original intent of the exam was to recreate reliable, unbiased assessments of student performance (Gormley, 2011), this objectivity was not observed in this research. Several medical students, from both the intervention and control campuses, echoed the same sentiment: the OSCE was an artificial experience (MS2-03C), something to simply get through (MS2-04C), and does not mimic actual practice (MS3-01). This feeling was in contrast to participating in simulations, which helped to prepare IUSM-B medical students for actual clinical encounters (MS3-03).

Cazzell and Howe (2012) conducted a study of nurse OSCE inter-rater reliability and discovered that, although acceptable inter-rater reliability was achieved for cognitive and psychomotor domains, unacceptable inter-rater reliability was obtained on the affective domain. Validity studies of OSCEs are also inconclusive, with reported correlation coefficients comparing OSCE to other measures of clinical competence as low as 0.10; thus, the value of the OSCE has been, "long assumed but has yet to be concretely proven" (Turner & Dankoski, 2008, p. 577). Furthermore, OSCE scores have

not been shown to reflect clinical reasoning abilities of medical students (Park et al., 2015). Therefore, it appears from the present research findings and the literature that OSCEs are flawed in some respects. Future directions should investigate the impact of HFPS on actual clinical competence, such as using preceptor evaluations (which is further explored in Chapter 8), rather than comparing HFPS experience to standardized examinations such as the OSCE.

Both the intervention and control populations had common interview statements about the OSCE that either revolved around the inflexible nuisances encountered for OSCE scoring (e.g., point deductions for not listening to abdominal quadrants for a long enough period of time), or the lack of guidance received prior to taking the exam. The claims from some medical students related to lack of clear learning objectives and inadequate guidance for successfully passing the OSCE are unexpected given the extensive materials that the administrators of the IUSM OSCE explained that they provide to students.

According to the Medical Student Assessment Program Manager in the IUSM Office of Medical Student Education, medical students are provided an orientation prior to their OSCE that reviews basic information about the flow of the exam (including the timing of encounters), general expectations (for instance, how to use the computer for documentation), and common reminders (such as avoidance of invasive procedures and where to find needed equipment in the exam room). All assessments are linked back to learning objectives provided in their course syllabi. Preparatory OSCE materials are made available to students online at least three months prior to testing, and includes: a general outline of what to expect for the exam, what is actually being measured,

instructions for the day of the test, and a list of online and text resources to guide their studies. All preparatory materials are developed by faculty and course directors working with personnel in the Office of Medical Student Education and distributed electronically from the statewide course director to the students at all nine campuses within IUSM. Specific OSCE grading rubrics and checklists are considered case confidential and are not released to students in order to maintain exam integrity (B. Herriott, personal communication, January 22, 2018).

Four medical students in this present study suggested that their medical program provide a model example of the entire history and physical exam structure that was expected for successfully completing the OSCE. Providing this example would be consistent with the literature on the importance of modeling, which has been shown to facilitate the development of expertise, foster expert critical thinking skills, and the thought-processes needed of an expert (Anderson et al., 2008). For example, LeFlore and colleagues (2007) discovered that instructor-modeled learning was superior to self-directed learning (SDL) among 16 nurse practitioner students in a clinical simulation using SimBaby programmed to display respiratory distress associated with asthma.

Ironically, articles authored by authority figures (such as faculty, administrators, etc.) claim that OSCEs are reliable, valid, and fair assessment tools (Carraccio & Englander, 2000; Gormley, 2011; Rentschler, Eaton, Cappiello, McNally, & McWilliam, 2007; Selim, Ramadan, El-Gueneidy, & Gaafer, 2012; Zayyan, 2011). However, when eliciting student perceptions regarding OSCEs, many articles report opposite findings. In a study of 119 dental students, only 22.7% thought the tasks that they were asked to perform were fair, one-third of students did not agree that the OSCE scores were a valid

indication of their ability, and the majority of students generally regarded the validity and reliability of the OSCE as low and unsatisfactory (Nazzawi, 2017). Another study of 246 senior medical students reported that 54.7% disagreed that the OSCE was fair, 53% disagreed that the OSCE assessed practical, real life scenarios, 77.7% believed that the OSCE was not a true measure of their clinical skills, and 81.3% were concerned regarding inter-rater variability and bias affecting their scores (Alghamdi, Katib, Alhoqail, & Al-khatib, 2016).

The previous examples of negative student perceptions regarding OSCE assessments aligns with the findings in this dissertation research and allude to a potential disconnect between the intentions of the OSCE and the reality of clinical practice. The IUSM OSCE should be continually evaluated and augmented to better align with the needs of authentic clinical practice. Recall that some IUSM-B medical students viewed HFPS as a method to help them prepare for actual clinical encounters, while they viewed the IUSM OSCE as a simple box-checking examination that had little practical relevance. Therefore, it appears that IUSM administrators should incorporate learning objectives and clinical skills utilized within HFPS in the OSCE.

A disconnect exists between what the IUSM OSCE intends students to learn and are expected to do, compared to what the students perceive as the utility of the OSCE. Several IUSM medical students found the OSCE to be a simple exercise of memorizing the script and procedures to obtain a passing grade, rather than viewing this exam as an opportunity to practice techniques and procedures that they will utilize in a real hospital setting during their future medical practices.

Finally, medical students in this study did not view HFPS as a replacement to real-world experience, but rather as an experiential supplement to traditional coursework. This view is consistent with the literature. For instance, Kameg et al. (2010) discovered that although 38 senior nursing students experienced increased self-efficacy of their communication skills with psychiatric patients after participating in HFPS compared to traditional lecturing, these students did not agree that simulation could replace real-world training. Coombs et al. (2017) echoed this sentiment while describing a clinically relevant simulation-based anatomy curriculum, explaining that rather than replacing traditional teaching methods, simulation can be incorporated as an adjunctive pedagogy. The intent of HFPS is not to replace the need for learning in real clinical environments, but to equip leaners with the preparation needed to enhance those real-world experiences and ultimately improve patient care (Maran & Glavin, 2003).

This research did discover a wide range of perceptions regarding the utility and perceived satisfaction with HFPS. As was discovered in a simulation-based investigation by Landeen and colleagues (2015), faculty must recognize student variation and support those students who are skeptical toward simulation. Perhaps rapid technological advancements (discussed further in Chapter 8) will support and aid those students who were unable, or unwilling, to suspend their disbelief while participating in HFPS. The authenticity of the HFPS experience has been previously called into question (Pike & O'Donnell, 2010); however, even if the manikin is not "real," the psychological immersion was important for most IUSM-B medical students in this study to acclimate to the feeling of being in an actual hospital room environment, become familiar with

medical supplies and equipment, and obtain practice working and communicating as a

healthcare team during IPE simulations.

The previous chapter focused on the quantitative impact of HFPS in medical

education to investigate Research Questions 1 and 2, while this chapter presented a

qualitative study regarding the utility of HFPS for medical students, addressing Research

Question 3a. The next chapter will conclude the qualitative investigation of HFPS by

focusing on medical resident viewpoints using a unique qualitative strategy, known as Q-

methodology. Chapter 8 concludes this dissertation work, presenting general conclusions,

evidence-based recommendations, the limitations of this work, and future directions that

may be explored.

CHAPTER 7: QUALITATIVE RESULTS AND ANALYSIS OF MEDICAL

RESIDENT PERCEPTIONS REGARDING THE UTILITY OF HIGH-FIDELITY

PATIENT SIMULATION

The quantitative analyses of this dissertation research were presented in Chapter 5

and Chapter 6 presented one of the qualitative portions of this research, but focused

solely on medical student perceptions regarding the utility of high-fidelity patient

simulation (HFPS) in medical education. The qualitative method presented in Chapter 6

was the directed approach to qualitative content analysis (QCA) and was used to analyze

medical student interview transcripts.

Another qualitative analysis method is known as **Q-methodology**, and is a

technique used to elicit perceptions, known as 'viewpoints' in Q-methodology, from

participants about a specific topic of interest. Several Q-methodology studies have been

conducted in medical education. For example, Meade and colleagues (2013) described

the Q-methodology sorting process as a game for an internal medicine residency program

and Berkhout and colleagues (2017) investigated the self-regulated learning (SRL)

behavior of medical students using Q-methodology during their clerkships. However,

little is known about the distinct patterns of medical resident perceptions of HFPS

experienced during undergraduate medical education (UME). Once identified, better

strategies may be developed for incorporating HFPS into medical education, and Q-

methodology studies are ideal to examine and elucidate these perceptions. With the goal

of improving the understanding of the impact of HFPS in medical graduates, the

following research question was addressed using Q-methodology: "How do medical

residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?" Eliciting the perspectives of those residents who have experienced HFPS, subsequently graduated, and are currently working in the healthcare field adds to a more comprehensive understanding of HFPS in medical education and beyond into residency training. Learning the subjective viewpoints of medical residents about HFPS is important to understand the impact of this educational strategy.

Methodology

A brief description of the methodology will be presented in this section. First, Q-methodology will be introduced; the recruitment of medical residents and a description of the Q-study administration follows; then a detailed explanation of each step of the Q-methodology process concludes this section of this chapter. A more comprehensive analysis of the methodology presented here is described in Chapter 3 of this dissertation.

Q-Methodology Background

Q-methodology is a research technique used to obtain qualitative subjective, or first-person viewpoints, by a quantitative inverted factor procedure that will be described shortly (Brown, 1980). Like some forms of qualitative analysis, one approaches Q-methodology without *a priori* hypotheses. Watts and Stenner (2012) stated, "abduction and discovery, not deduction from *a priori* premises, ordinarily provide a foundation for strong Q-methodological studies" (p. 53), and "Q-methodology and abduction represent a system for generating, evaluating and adapting explanatory theories, not for testing them" (p. 96). Q-methodology does not have specific pre-existing hypotheses or conclusions,

but instead asks participants to sort diverse previously determined statements relative to each other based on their subjective opinions. The statements are derived from a literature review, interviews, focus groups, observations, and/or popular texts, such as magazines or televisions programs depending on the particular area to be researched (Watts & Stenner, 2012). Individuals are then grouped based on their broad opinions as a whole, rather than by the opinions derived from specific, targeted questions. Q-methodology employs by-person factor analysis in which the participants become the variables that are mathematically clustered based on the shared viewpoints among the participants (Barbosa et al., 1998; Paige, 2014). While the term 'Q-methodology' refers to the philosophy of investigating subjectivity, the term 'Q-study' refers to the actual data collection that occurs to investigate a research question within the Q-methodology framework (D. Hensel, personal communication, June 5, 2018).

One of the strengths associated with Q-methodology resides in its ability to obtain rich data with a relatively small sample size (Hensel, 2016). Although there is no definitive minimum sample size for Q-studies, Watts and Stenner (2012) advised that 40-60 participants is sufficient. However, other Q-methodology studies within health science literature have reported using much smaller samples sizes, for example: 7 emergency medical staff members (Chinnis et al., 2001), 12 faculty (Landeen et al., 2015), 22 medical residents (Fokkema et al., 2014), 24 undergraduate nursing students (Baxter et al., 2009), 28 nursing faculty (Akhtar-Danesh, et al., 2009), and 35 nursing and medical students (Hee & Euna, 2016).

A sequential procedure guides the Q-methodology process (see Figure 3.5) along with specific terminology. First, the concourse must be created. The **concourse** is a

collection of opinion-focused statements representing the breadth and depth of a particular phenomenon, and as described above, is derived from the literature, focus groups, interviews, observations, and/or surveys. For the present research of HFPS, the concourse consisted of 77 statements related to simulation in medical education derived from the literature review (Chapter 2) and observational and interview data from the pilot study (Chapter 4).

Next, the concourse was condensed and refined to create the Q-sample. The **Q-sample** is a selection of statements that represent a broad range of opinions derived from an iterative consensus process of the concourse. A similar procedure described by Berkhout et al. (2017) was used to condense the concourse to the Q-sample (Figure 7.1).

Figure 7.1: Flowchart depicting the iterative consensus process used to finalize the Q-sample from the concourse
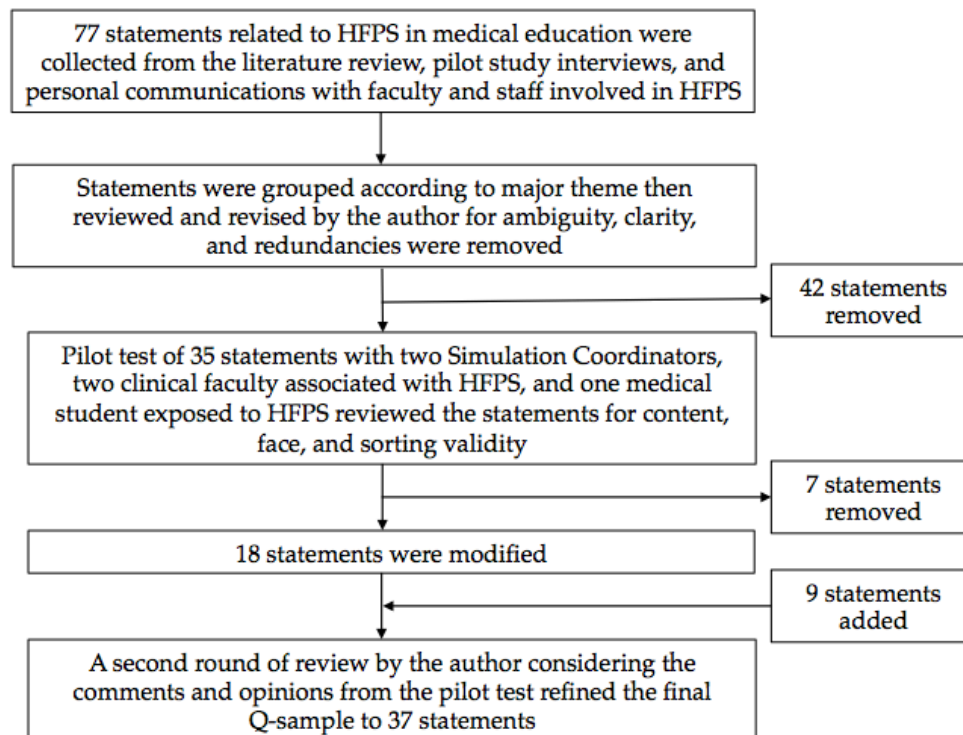
The original concourse for this research consisted of 77 statements that the author then grouped according to major themes. Brown (1980) suggests reviewing the concourse and organizing each statement by general subject to expose redundancies for subsequent elimination. Redundancies within each theme were deleted by the author, leaving 35 statements. Then these 35 statements were reviewed for content and face validity, and revised for ambiguity and clarity, by a panel of experts (including two Simulation Coordinators and a faculty member knowledgeable about simulation) and one volunteer medical student who had experienced simulation (Appendix G). From the pilot test with the panel of experts and one volunteer medical student, seven statements were deleted, 18 statements were modified, and nine statements were added. A final round of review incorporating the pilot test comments refined the final Q-sample to 37 statements (Appendix H) derived from the original 77 statements of the concourse.

After the rigorous validation process, the Q-sample was finalized. Another small pilot test was done with the final 37 statements using two volunteer medical students to ensure Q-sorting validity and final refinement of statement phrasing. Recall from Chapter 3 that Q-methodology reliability is verified by a test-retest procedure (usually at one-week and two-week intervals) and intra-individual correlations have been found to be .80 or higher (Akhtar-Danesh 2008; Brown 1980). Given logistical limitations and time constraints imposed on this project, reliability of the Q-sample could not be verified.

The finalized Q-sample was then digitally created using an electronic sorting software platform known as Q-sortware (Pruneddu, 2011), described in more detail below. During recruitment, participants were notified of the ability to receive a mailed manual sort option if they requested; no participants opted for the manual sort.

Recruitment for the Q-study

Recruitment of the medical residents for the Q-study was challenging. Only three IUSM-B medical classes (the class of 2015, 2016, and 2017) had the opportunity to participate in simulations for at least one year within the IUBIPSC since its construction and had recently graduated at the time of this study (Table 7.1).

First, residency match lists were obtained for the three medical school years from the Office of Medical Student Education (MSE) website at https://mednet.iu.edu. These lists contained the names, specialty, and hospital or institution where the medical student was matched to after graduation. Then, a manual Internet search of these names found 40 publically available email addresses, and all were sent a personalized initial email invitation to participate in the study. This initial invitation was followed by two reminder emails if the medical resident did not complete the study. These reminder emails were sent about two to three weeks apart. All of these emails were sent in August, September, and October 2017. Every email also asked the recipient to forward the invitation to peers within their medical school class that they are still in contact with for inclusion in this study, thus implementing **network sampling** (also referred to as 'chain,' 'chain-referral,' or 'snowball sampling').

A request was sent by the author to the Director of Alumni Relations at the Indiana University School of Medicine Alumni Association with the 36 resident names, specialties, and match locations that could not be found online. The Director of Alumni Relations found 32 email addresses for these residents and sent them to the Principal Investigator (PI) listed on the IRB approved protocol of this research (VDO). This process was done so that the main author of this research (BK) would not be contacting

the residents directly through the alumni association. The PI later reported to the author

that four residents did not have email records according to the Director of Alumni

Relations; therefore, the PI sent a general email invitation to 32 residents. The PI

informed the author that a "delivery status failure" notification was received for 14 of

these email addresses. Therefore, 58 medical residents, out of a total of 76, were

contacted at least once to participate in this Q-study. Of the 58 medical residents

contacted, a total of 12 medical residents agreed to participate in the study, and their

demographic data will be discussed later in this chapter.

Q-study Administration

In the invitation emails, medical residents were provided with a link to access the

study through a web-based software application known as Q-sortware (Pruneddu, 2011).

This online Q-sorting software platform guided participants through the Q-sort process

step-by-step. An initial splash page (Figure 7.2) explained the study's purpose, goal, that

the participant would be entered into the random drawing for a $100 Amazon.com Gift

Card upon submission of the Q-sort, and a notice that all information would remain

confidential.

Figure 7.2: Screen capture of the initial Q-study splash page
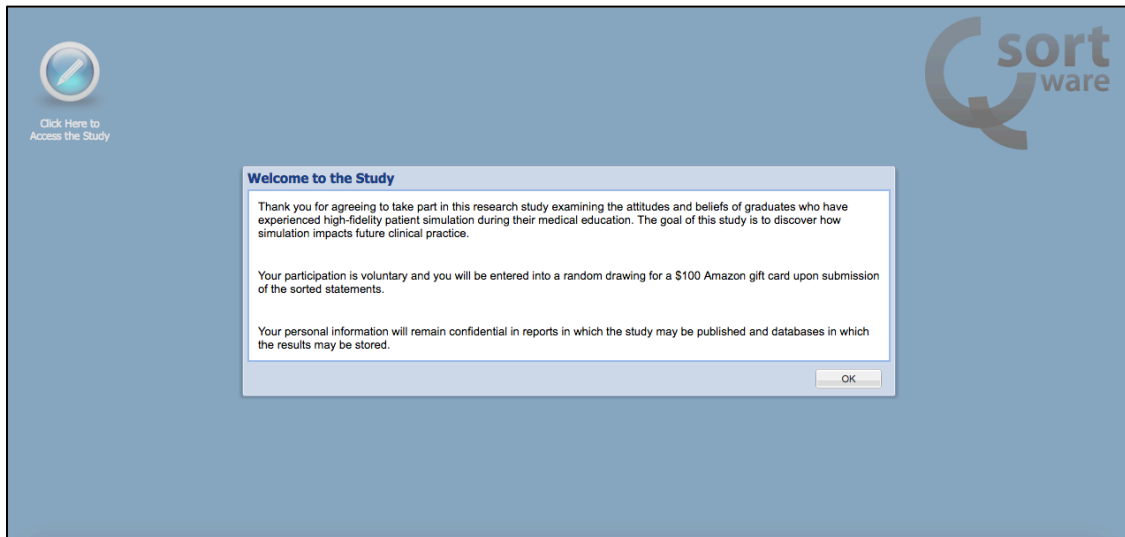
The next screen brought participants to the first round of sorting (Figure 7.3).

Instructions at the top of the page asked participants to reflect on their simulation training

in the IUBIPSC within the context of their current career, provided a definition of

simulation for context ("High-fidelity patient simulation (hereafter referred to as

'simulation') is a simulation center that physically recreates a hospital room and includes

a technologically-advanced manikin that is able to realistically respond to

interventions."), reminded residents of the IUBIPSC layout ("The simulation center at

IUSM-Bloomington had two simulated clinical environments: an Intensive Care Unit

(ICU) room and an Obstetrics and Gynecology (OB/GYN) Labor and Delivery room and

included interactive manikins with a voice by Sally Gindling, the Simulation

Coordinator"), and a notice to participants while sorting to consider all of their simulation

experiences at IUSM-B as a whole, rather than one or two specific instances, which has

been cited as a limitation in Q-methodology studies (Baxter et al., 2009).

During this first round of sorting, participants were asked to electronically sort the 37 Q-sample statements into three groups (Agree, Neutral, and Disagree) according to how well the statements described their opinion regarding HFPS experienced during their medical education at IUSM-B. The software allowed participants to drag-and-drop their choice of statement into the appropriate group. Each statement was presented randomly, one-at-a-time, and there was no limit imposed as to the number of statements that could be assigned to each group.

Figure 7.3: Screen capture illustrating the first round of Q-sorting

After all of the statements had been sorted into one of the three groups, the "Continue" button at the bottom of the screen became active and brought participants to the second round of sorting (Figure 7.4). Instructions at the top of this page informed participants that they would see the same 37 statements and they were to further refine their sort of the statements by placing the statements in one of the cells of the grid according to their opinion (Strongly Agree, Moderately Agree, Agree, Slightly Agree,

Neutral, Slightly Disagree, Disagree, Moderately Disagree, or Strongly Disagree) while continuing to think about the application of HFPS experienced during their medical education.

Figure 7.4: Screen capture of the second round of Q-sorting

The software allowed participants to drag-and-drop their choice of statement into the appropriate column within the grid. The columns of the grid represented the typical grid seen in Q-methodology studies, which is a bipolar and inverted quasi-normal distribution, that contains as many cells as Q-statements, and includes two anchors (see Figure 3.6). Participants were informed that they could only place the specific number of statements indicated within each column, each column must be filled with that number of statements before continuing, and it did not matter which statement appears on top or on bottom of another statement within each column. Two statements were allowed in the Strongly Agree column; three statements were allowed in the Moderately Agree column, four statements were allowed in the Agree column; six statements were allowed in the

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Slightly Agree column; seven statements were allowed in the Neutral column; six statements were allowed in the Slightly Disagree column; four statements were allowed in the Disagree column; three statements were allowed in the Moderately Disagree column; and two statements were allowed in the Strongly Disagree column.

Participants were then directed to the next screen, which included two open-ended questions allowing them to elaborate on their reasoning for the highest (Strongly Agree +4) and lowest (Strongly Disagree –4) ranked statements (Figure 7.5). The open-ended question responses were considered along with the quantitative results from factor analysis to support the interpretation of groups of participants within each factor (Berkhout et al., 2017).

Figure 7.5: Screen capture of the open-ended questions page of the Q-sort procedure
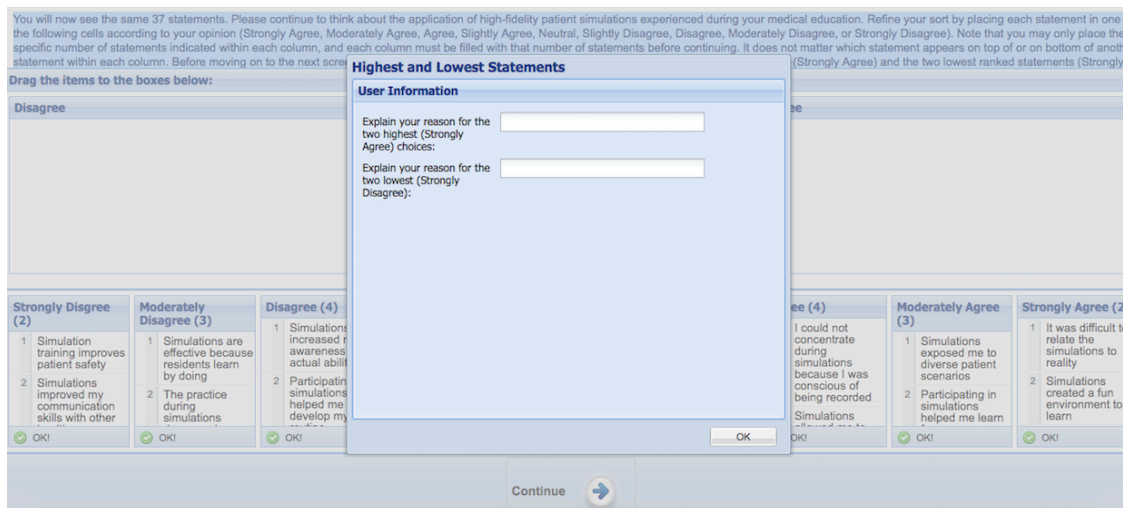
The final screen asked participants for general demographic data, and included: email address, sex (male/female), age, current position and location of employment, and a dichotomous variable asking if the resident would be willing to participate in a brief follow-up interview regarding their Q-sort (Figure 7.6).

Figure 7.6: Screen capture of the demographic data page of the Q-sort procedure
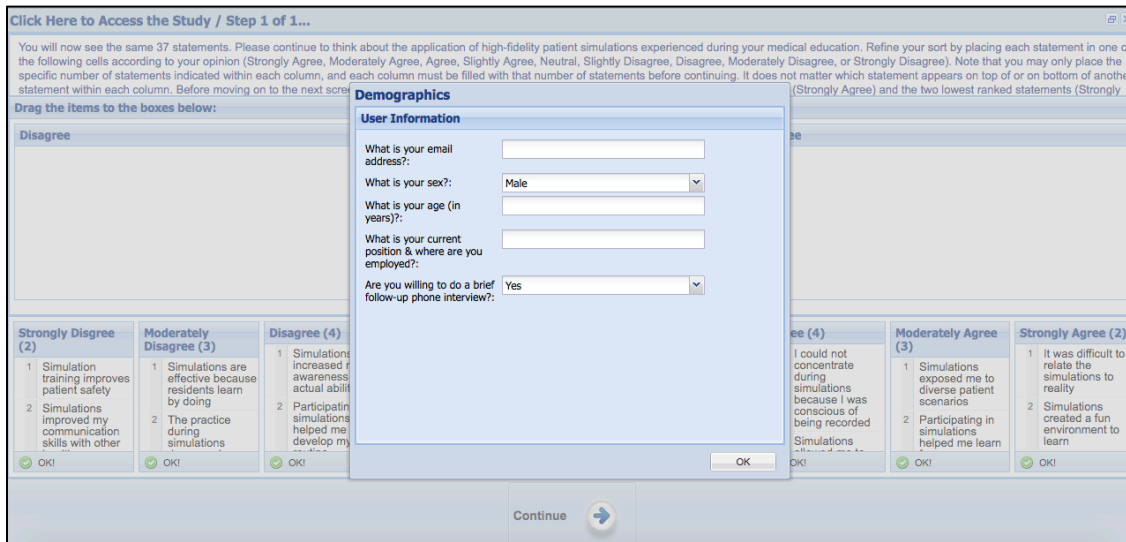
Factor analysis and factor rotation were conducted using Ken-Q Analysis©,

Version 1.0.1 (Banasick, 2016). This web-based, open-source software is a client-side

application, in which there is no communication with the server once the page is loaded.

Therefore, all calculations and files are produced locally within the browser for ensured

data security. This web-based software was utilized rather than the program that is

typically cited in Q-methodology literature, known as PQMethod (Schmolck & Atkinson,

2014). While both the Ken-Q Analysis© web-based software and the PQMethod software

are open-source, Ken-Q Analysis© was used for this research mainly because of its user-

friendly interface. PQMethod uses a DOS-based program, which necessitates a learning

curve to use the program, in addition to learning the factor analysis required for Q-

methodology.

Responses to the open-ended questions presented after the sorting and follow-up

interviews aid in factor interpretation. All participants that consented to a follow-up

interview (6 residents) were contacted in February 2018. Ultimately, one medical resident

agreed to an interview (Table 7.1). The supplementary interview consisted of semi-structured questions (Appendix K) and the interview data was incorporated into the factor interpretation to provide a more comprehensive understanding for factor interpretation.

Q-methodology Factor Analysis

There are two main strategies used to analyze Q-methodology investigations: inductive and deductive (Watts & Stenner, 2012). When researchers approach the data without preconceived notions of how many factors will be present, thus allowing the data to guide the interpretation, an **inductive approach** is taken. This approach to analysis is similar to exploratory factor analysis (EFA) seen in factor analysis literature. Conversely, when circumstances have created predetermined factors or factor loadings when entering the data analysis stage, a **deductive approach** to Q-methodology analysis is said to occur. This vaguely hypothesis-driven strategy is associated with confirmatory factor analysis (CFA).

Although Watts and Stenner (2012) argued that, "pure induction is a philosophical fallacy" (p. 96), because academic researchers tend to harbor expectations about the subject matter leading to predetermined expectations, the inductive approach to Q-methodology analysis was utilized for this research for several reasons. First, although Q-methodology studies regarding simulation have been undertaken in the literature (Akhtar-Danesh et al., 2009; Baxter et al., 2009; Ha, 2014; Landeen et al., 2015; Yeun et al., 2014), and Q-methodology studies involving medical populations have been reported (Barbosa et al., 1998; Berkhout et al., 2017; Block, 1994; Fokkema et al., 2014; Gaebler-Uhing, 2003; Hee & Euna, 2016; Meade et al., 2013; Valenta & Wigger, 1997;

Wallenburg et al., 2010), to the author's knowledge to date, no Q-methodology study

exists that combined HFPS with medical residents' as the study focus. This novel

approach to answering Research Question 3a left the author with little foresight into the

viewpoints and perceptions of medical residents who experienced HFPS during their

medical education and were currently working in the healthcare field.

Five sequential steps of statistical procedures guide the Q-methodology data

analysis process:

1. Calculate correlations between the Q-sorts.

2. Conduct the factor analysis.

3. Perform a factor rotation.

4. Compute the factor weights and factor scores.

5. Interpret the factors.

Each of these steps will be now be discussed in detail.

1. **Calculate correlations between the Q-sorts.** The scores (+4 to –4) assigned to

each Q-statement for each participant form the basis for calculating the Pearson

(*r*) product-moment correlation coefficients between each pair of Q-sorts in the

study (Brown, 1980). The resulting **correlation matrix** provides numerical

confirmation of the relationships between two Q-sorts, indicating the extent of

similar or differing viewpoints between individual participants within the Q-study

(McKeown & Thomas, 2013). For instance, a correlation of +1.00 signifies that

two Q-sorts are exactly the same (two different participants placed every

statement in the same orientation), while a correlation of –1.00 would be seen in

the event that two different participants placed their Q-statements exactly in reverse order from each other (indicating opposing beliefs). Both cases of perfect correlations are extremely rare (Brown, 1980), but the higher the positive correlation, the more two Q-sorts have similar configurations (and hence the two participants have similar beliefs on the topic).

Significant correlations are calculated as the standard error (*SE*) multiplied by 2.58 for $p \leq .01$ level or 1.96 for $p \leq .05$ level (Dennis, 1986), which mathematically is represented as 2.58(*SE*) and 1.96(*SE*). The $SE = 1/\sqrt{N}$, where N is the number of items in the Q-sample. It is unclear in Q-methodology if the $p \leq .01$ level or $p \leq .05$ level is preferred for interpretation. Convention in applied statistics is to report magnitudes of results occurring due to chance fewer than five times out of 100 ($p \leq .05$) "and/or" (Brown, 1980, p. 283) fewer than one time out of 100 ($p \leq .01$). Of the Q-methodology studies reviewed, it appears that the $p \leq .01$ level is most commonly utilized (Brown, 1980; McKeown & Thomas, 2013; Valenta & Wigger, 1997; Watts & Stenner, 2012), although reason for this is lacking. Therefore, $p \leq .01$ was used for the present study to determine statistically significant correlations and factor loadings. In this research, $N = 37$, so the computation is, $2.58(1/\sqrt{37}) = \pm.42$. Therefore, $\pm.42$ would define a statistically significant correlation at $p \leq .01$.

The correlation matrix is the first step in understanding the relationships among the Q-sort participants and their patterns of similar and differing viewpoints, but it is not particularly helpful on its own as it represents a "transitional phase between the raw data and factor analysis" (Brown, 1980, p.

207). However, the correlations are the data used for factor analysis in step 2, and all correlations are retained for the next step since removing a Q-sort would alter the overall meaning and variability of the study (Watts & Stenner, 2012). Statistically significant correlations allude to similar Q-sorts representing the same factor; however, further factor analysis is required to confirm which Q-sorts should be grouped together.

2. **Conduct the factor analysis.** The correlation analysis is followed with a by-person factor analysis that statistically groups participants into factors corresponding to the patterns of opinions based on their Q-sort. Factor analysis is considered a data reduction technique; therefore, there will be fewer factors than Q-sorts as individuals are grouped based on their common sorting patterns. The mathematics underlying the factor analysis procedure are complex, the details of which go beyond the scope of this work, but are completely articulated in Brown (1980). However, factor analysis is easily computed by the Ken-Q Analysis© software that was utilized for the present study. Three decisions must be made for this step: the type of factor extraction, how many initial factors to extract, and how many factors to keep for continued analysis.

There are two types of basic factor extraction methods: **principal component** and **centroid**. Watts and Stenner (2012) advised conducting the centroid method over principal component analysis (PCA), although both methods will usually provide similar results. While PCA will provide the best single mathematical solution, it has been criticized as a simplistic approach to factor extraction and is not ideal to Q-methodologists who desire an opportunity

to explore the data through factor rotation and theoretically informed knowledge. The centroid method is the oldest factor extraction technique, allows for factor rotation, and is used in manual (by-hand) extraction of factors (Watts & Stenner, 2012). The centroid method was used for this research.

Although objective criteria exist regarding the number of factors to extract with centroid factor extraction, a slightly arbitrary, yet widely used criterion is "the magic number 7" (Brown, 1980, p. 223), which is the extraction of seven initial factors. This is likely more factors than believed will be significant; however, Brown (1980) recommends that it is advantageous to extract more factors than expected at this early stage because insignificant factors can help improve the loadings on a major factor. After factor rotation, these insignificant factors are discarded from the remainder of the analysis if they do not significantly contribute to the final factor solution.

The result of centroid factor extraction of seven factors will yield a table (referred to as the "Unrotated Factor Matrix") of the **unrotated factor loadings** for each participant. These unrotated factor loadings, computed from the configuration of the correlations, indicate the amount that a participant's Q-sort correlates with a particular factor compared to other participant's Q-sorts in the study (McKeown & Thomas, 2013). These factor loadings are considered "unrotated" because they have yet to undergo the third step of Q-methodology.

The last procedure of this step requires the researcher to determine how many factors to keep based on the unrotated factor loadings. Several criteria exist to accomplish this, including the Kaiser-Guttman criterion and observation of the

scree plot (both were assessed for the present study). The **Kaiser-Guttman criterion** explains that only factors with an eigenvalue greater than 1.00 are considered significant (Guttman, 1954; Kaiser, 1960, 1970), and thus should be kept, as any less would indicate that the variance is less than a single Q-sort (Watts & Stenner, 2012). Eigenvalues represent the sum of squared factor loadings and each eigenvalue equals the percentage of the total variance in the study accounted for by the particular factor (McKeown & Thomas, 2013). This is a generally accepted criterion in the factor analytic community for justification of extracted factors, although it is also acceptable to extract one factor per six to eight participants in the study (Watts & Stenner, 2012).

Another criteria to determine factor significance is based on the slope of the line of the scree plot. The **scree plot** (Figure 7.7) is generated during factor analysis and the number of factors to keep is indicated by the point at which the line of the scree plot changes slope (Watts & Stenner, 2012). After the number of factors to retain is determined, the factors can be rotated to obtain the most precise mathematical factor orientation.

3. **Perform a factor rotation.** In order to simplify and more easily interpret the factors, a rotation of the factors may occur. Since the factor loadings obtained from centroid or PCA factor extraction represent coordinates in a three-dimensional spatially arranged matrix, the loadings can be augmented (i.e., rotated) to reflect a more appropriate conceptual arrangement of factors given the specific Q-sort rankings (Brown, 1980). There are two basic types of factor rotation: judgmental (manual, or by-hand) and varimax (Watts & Stenner, 2012).

The **judgmental rotation** method is a manual or by-hand method. It was not used for this study because judgmental rotation requires more skill and knowledge than a beginning Q-methodologist possesses, has been cited to lead to potentially subjective and unreliable results, and many journals will not accept a factor solution that has been derived through this rotation method (Watts & Stenner, 2012). In contrast, **varimax rotation** is an objective and reliable method that determines the optimal angle to analyze the factor structures while maintaining the orthogonal orientation (maintenance of the 90-degree relationship between the factor axes) of the original extracted factors. The varimax rotation method is a more structured method, but it does find the best mathematical solution for the factor rotation based on the maximum variance across the fewest number of different factors (Barbosa et al., 1998). Varimax rotation was applied to the retained factors in the present study.

It is important to remember that the structural positions and relationships among the factors are still maintained during factor rotation; the rotation simply maps the geometric configuration of the factors through three dimensions of space (X, Y, and Z axes) to obtain the most accurate orientation. Factor rotation produces another table (referred to as the "Rotated Factor Matrix") of the **rotated factor loadings** for each participant. Recall from step 1 that statistically significant correlations are determined by calculating 2.58(SE) for $p \leq .01$, where $SE = 1/\sqrt{N}$, and N is the number of items in the Q-sample. Again, the $p \leq .01$ was considered statistically significant in the present study for consistency; therefore, ±.42 would define a statistically significant rotated factor loading, and thus best

define the factor. From the rotated factor loadings, factor weights and factor scores can be calculated.

4. **Compute the factor weights and factor scores.** The rotated factor loadings indicate how similar a participant's views are to other participants in the study. Observation of the rotated factor loadings will reveal that some participants more closely approximate the factor than others within the same factor. Communalities are provided, denoted as h^2, and are calculated as the sum of squared factor loadings (Brown, 1980). Expressed as a percentage, **communalities (h^2)** represent proportion of variance explained with the other Q-sorts (Akhtar-Danesh, 2016). In other words, h^2 represents how much an individual Q-sort holds in common with all of the other Q-sorts in the study; the higher the communality, the higher the individual Q-sort represents the factor group. The differences between the rotated factor loadings for each participant within the same factor must be taken into account before the final factor score (described later) is calculated. Therefore, factor weights must be calculated from the rotated factor loadings.

Factor weights are calculated using the following formula: $w = f / (1 - f^2)$ where w is the factor weight and f is the factor loading. Factor weights describe the magnitude of how much a single Q-sort approximates the factor compared to other Q-sorts in the same factor. Factor weights are also used to calculate factor scores in the next step of the procedure.

The rotated factor loadings and the factor weights are mathematically merged to create the common viewpoints among all participants within each factor. The mathematical basis for the merging is done by the Ken-Q Analysis©

software; for a detailed description, refer to Brown (1980). The merging includes

weighting, averaging, and normalizing (converted into z scores with $M = 0.00$ and

$SD = 1.00$) the statement rankings of each participant within the factor to allow

for comparisons of statement scores across all factors, regardless of the number of

participants assigned to each factor or their differing factor weights (Berkhout et

al., 2017; Scott, Baker, Shucksmith, & Kaner, 2014). The merging process results

in a single, **idealized Q-sort** (or 'model Q-sort,' or 'composite factor array') for

each factor, which represents all participants within each retained factor. The

table is populated with **factor scores** ranging from +4 to –4 for each statement,

and reveals the level of agreement and disagreement of each statement within a

factor (Valenta & Wigger, 1997).

The idealized Q-sorts also present three types of statements that aid in

factor interpretation: distinguishing statements between factors, consensus

statements across factors, and characterizing statements within factors.

Distinguishing statements (also known as 'divergent statements') are statements

that are ranked in a statistically significantly position by participants in one factor

compared to participants in another factor. **Consensus statements** are placed in a

statistically significant similar position for all participants in the study, while

characterizing statements are those specific statements placed in the two

columns of the polar extremes (+4 and –4) of the Q-sort grid for each factor (see

Figure 3.6). The statistical significance of these statements must be at least at the

$p \leq .05$, although some may be at the $p \leq .01$ level (Coogan & Herrington, 2011;

Paige, 2013). This commences the mathematical analysis of Q-methodology,

providing investigators with data to then qualitatively interpret the fundamental

viewpoint of each factor.

5. **Interpret the factors.** Arguably, factor interpretation is the most challenging step

of Q-methodology because there is no detailed formulaic strategy to guide the

analysis as in steps 1–4 (Brown, 1980; Watts & Stenner, 2012). Here is where the

qualitative aspect of Q-methodology is truly revealed. During factor

interpretation, the idealized Q-sorts, the consensus, distinguishing, and

characterizing statements, qualitative data from open-responses from the final step

of the Q-sort procedure (Figure 7.5), and follow-up interviews conducted with the

Q-sort participants after they complete the sorting procedure are all considered

while interpreting the viewpoint of each factor.

During factor interpretation, the researcher ruminates with all of the data

and creates a categorical label assigned to each factor to accurately describe the

group of participants based on their viewpoint of the study's subject. Three

descriptors presented later in this chapter (Factor 1: Practical Skeptics; Factor 2a:

Simulation Enthusiasts; and Factor 2b: Anxious Supporter) were developed by the

author, and then subsequently confirmed with a Q-methodologist for appropriate

interpretation. However, it is important to remember that while the interpretation

of participants within each factor is grounded in quantitative and qualitative data,

the final interpretation is just that — an interpretation. As with all qualitative

research, two different Q-methodologists can analyze the same data and

potentially reach different conclusions. Watts and Stenner (2012) suggested that

since "the end product isn't perfect" (p. 163), checking the interpretation with one

or two of that factor's significantly loading participants may help to confirm the interpretation (similar to conducting member checks described in Chapter 6). However, it should be noted that the interpretation will not be an exact replica of the personal viewpoint of any one participant, as it was derived from a conglomeration of all participants within the factor.

Results

The results of the Q-study will be presented in three sections. First, general demographic data regarding the medical residents who participated in this Q-study will be described. This is followed by the statistical results obtained from factor analysis. Finally, factor interpretation will be elucidated, including a description of each of the three factors discovered. This chapter concludes with a discussion of the findings from this Q-study of medical residents and the implications that these findings have for HFPS as related to the existing literature, addressing Research Question 3b.

Q-Methodology Study Demographic Data

As described in Chapter 3, medical graduates from the entire IUSM-B classes of 2015 (*N*=6), 2016 (*N*=35), and 2017 (*N*=35) were invited to participate in this study because they had experienced at least one year of HFPS within the IUBIPSC, had subsequently graduated from their medical program, and were practicing medical residents at the time of data collection (Table 7.1). Note that the medical residents experienced a similar HFPS schedule to the medical students in Chapters 4 and 6. The first-year HFPS were the same; during the second-year, the medical residents experienced

five summation simulations, while the current medical students experience four summation simulations and one cardiology skills day; the third-year HFPS were the same (which included an advanced cardiac life support [ACLS] HFPS and a diabetic ketoacidosis [DKA] HFPS), except the medical residents did not have the progressive simulations that the current medical students experience (S. Gindling, personal communication, June 6, 2018).

As previously outline, due to limitations on current contact information, only 58 email addresses were obtained and all were invited to participate in the study. Network sampling was also employed, by asking the study participants in the invitation emails to refer colleagues from their medical classes for inclusion in the study.

Ultimately, 12 medical residents participated in the study and completed the Q-sort procedure (15.8% response rate). Recommendations of Q-study sample sizes advise at least 10 percent of the intended sample (Hertzog, 2008) or a ratio of one participant for every three Q-statements (Webler, Danielson, & Tuler, 2009). Published Q-methodology studies have reported sample sizes of seven (Chinnis et al., 2001), eight (Paige, 2013), and 14 (O'Leary, Wobbrock, & Riskin, 2013). Given the recommendation by Webler and colleagues (2009), 37 statements in the present Q-study would equate to about 12 participants; therefore, the sample size obtained was deemed adequate to continue analysis (D. Hensel, personal communication, May 24, 2018).

Two participants were from the IUSM-B class of 2015, one was from the IUSM-B class of 2016, and nine were from the IUSM-B class of 2017. Eight participants self-identified as male and four as female, ages were relatively homogenized, with a mean age of 26.75, and ranged from 24 years to 29 years. All participants identified as a resident

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with various areas of specialization across the United States, including: internal medicine

residencies in Indiana, Utah, Louisiana, Florida, Wisconsin, and Ohio; emergency

medicine residencies in New Mexico and Pittsburgh; an obstetrics and gynecology

resident in Ohio; and a surgery resident in Missouri.

Table 7.1: IUSM-B populations and samples used for the Q-methodology study

Medical Class Year	Class Size	Con-tacted	Response Rate (%)	Male	Female	Age (years)	Willing to Interview	Inter-viewed
2015	6*	4	2 (33.3)	1	1	28-29	1	1
2016	35	21	1 (2.9)	1	0	27	0	0
2017	35	33	9 (25.7)	6	3	24-28	5	0

* Unlike the other IUSM-B classes of 2016 and 2017, the class of 2015 only included 29 medical students; however, only six students stayed in Bloomington for their third year, and therefore, only these six students experienced simulations within the IUBIPSC prior to graduating.

Q-methodology Statistical Procedures

Recall that five sequential steps guide the Q-methodology process: 1. Correlation

calculation; 2. Factor analysis; 3. Factor rotation; 4. Computation of factor weights and

factor scores; and 5. Factor interpretation. Each step related to this study will be

explained next.

Step 1. Calculate correlations between Q-sorts.

The correlation table (Table 7.2) shows the Pearson (*r*) product-moment

correlation coefficients, one for each pair of Q-sorts, indicating the relationship between

two Q-sorts. Observation of the correlation matrix shows several significant correlations.

Recall that correlations were considered statistically significant at ±.42. Positive

correlations are noted between all Q-study participants, except Respondent 7, who

exhibited several negative correlations between other participants. This result may

indicate that Respondent 7 falls within an entirely distinct factor from the other

participants; however, this hypothesis must be further explored during the next step of the

Q-methodology process.

Table 7.2: Correlation matrix for medical resident Q-sorts

Q-sort	1	2	3	4	5	6	7	8	9	10	11	12
1	1	.14	.05	.12	.19	.40	.28	.03	.10	-.01	.06	.06
2		1	.42	.48	.36	.28	-.23	.52	.64	.27	.22	.19
3			1	.56	.23	.42	.14	.33	.47	.35	.41	.61
4				1	.27	.27	.01	.58	.56	.28	.27	.62
5					1	.49	-.04	.33	.50	.14	.31	.37
6						1	.24	.30	.31	.27	.38	.48
7							1	-.22	-.28	-.02	.48	.25
8								1	.70	.08	.35	.27
9									1	0	.14	.28
10										1	.25	.49
11											1	.39
12												1

Note that the first row and column of numbers in grey represent the individual
participants, 1 through 12, of the Q-study. Numbers within the table indicate the
correlation relationships between two Q-sorts. Significant correlations are noted in bold
and were calculated based on the standard error multiplied by 2.58 for the .01 level
(Dennis, 1986). Mathematically this is represented as 2.58(SE), where $SE = 1/\sqrt{N}$, and N
is the number of items in the Q-sample. In this instance, $N=37$, so the computation for
significant correlations is 2.58($1/\sqrt{37}$) = ±.42. Significant correlations allude to similar Q-
sorts representing a factor, which will be further elucidated in the next step of the Q-
methodology procedure.

Step 2. Conduct the factor analysis.

        The by-person factor analysis statistically grouped participants into factors

corresponding to the patterns in their Q-sort of opinions regarding HFPS. Recall that a

'factor' in Q-methodology represents the similar patterns or dimensions of shared

meaning that are present in the data. Seven initial factors were extracted by the centroid

factor extraction method producing the unrotated factor matrix (Table 7.3). The factor

matrix provides a visual summary of which Q-sorts are similar to or different from each

other. The numbers within the factor matrix are the unrotated factor loadings.

Table 7.3: Unrotated factor matrix

Respondent	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
1	0.23	0.07	0.00	-0.31	-0.17	0.13	-0.27
2	0.57	-0.39	0.10	0.04	-0.17	0.03	-0.08
3	0.71	0.06	0.00	0.33	0.06	0.09	-0.15
4	0.72	-0.16	0.01	0.27	0.19	0.08	-0.13
5	0.55	-0.07	0.00	-0.15	-0.29	0.11	0.10
6	0.68	0.22	0.04	-0.27	-0.35	0.22	0.07
7	0.10	0.76	0.74	-0.30	0.40	0.25	-0.23
8	0.57	-0.49	0.16	-0.04	0.16	0.02	0.16
9	0.60	-0.67	0.37	0.01	-0.06	0.01	-0.03
10	0.35	0.17	0.02	0.35	-0.05	0.10	0.25
11	0.57	0.24	0.04	-0.19	0.27	0.09	0.19
12	0.71	0.25	0.05	0.29	0.04	0.06	0.12

To determine the factors to keep for analysis, the Kaiser-Guttman criterion and

the scree plot were assessed. Recall that the Kaiser-Guttman criterion recommends that

factors with an eigenvalue greater than 1.00 are considered significant and should be

kept. Table 7.4 lists the eigenvalues for the seven factors. According to this criterion, two

factors (Factor 1 and Factor 2) should be kept for continued analysis.

Table 7.4: Factor eigenvalues and factor variances

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Eigenvalues	**3.7857**	**1.65645**	0.72284	0.70689	0.5672	0.18209	0.33122
% variance explained	**32**	**14**	6	6	5	2	3
Cumulative % variance explained	**32**	**46**	52	58	63	65	68

By convention, seven factors are initially kept (Brown, 1980) and are listed in the first row of the table. Eigenvalues are listed in the second row, and represent the sum of squared factor loadings; these values equal the percentage of the total variance in the study accounted for by the particular factor (McKeown & Thomas, 2013), which are listed in the subsequent rows. Eigenvalues greater than 1.00 are considered significant; therefore, Factor 1 and Factor 2 (in bold) were kept for continued analysis.

Another criteria to determine factor significance is based on the slope of the line of the scree plot (Figure 7.7). Recall that the scree plot is generated during factor analysis and the number of factors to be extracted is indicated by the point at which the line of the scree plot changes slope (Watts & Stenner, 2012). The slope of the line deviates between Factor 2 and Factor 3; therefore, two factors should be kept based on the scree plot. From the Kaiser-Guttman criterion and the scree plot, Factor 1 and Factor 2 were kept for continued analysis; the rest of the factors were discarded.

Figure 7.7: Scree plot of seven extracted factors
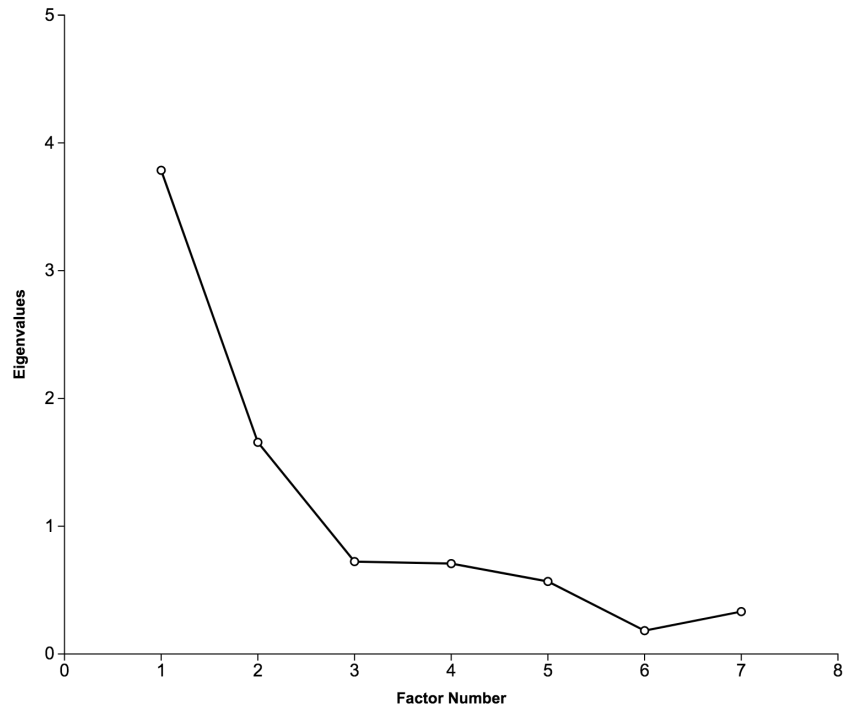
The scree plot is generated during the factor extraction step, and represents another strategy to determine significance of the extracted factors based on the slope of the scree plot (Watts & Stenner, 2012). The point where the slope deviates, between Factor 2 and Factor 3 in this scree plot, implies that Factor 1 and Factor 2 are significant and should be kept for continued analysis.

Step 3. Preform factor rotation.

Varimax rotation was performed on the two factors that were kept. The result of factor rotation yielded the rotated factor matrix with rotated factor loadings (Table 7.5). The rotated factor loadings represent how much a respondent explains a factor. Recall that rotated factor loadings were considered statistically significant at ±.42

Table 7.5: Rotated factor matrix

Respondent*	Factor 1 Loading	Factor 1 Weight	Factor 2 Loading	Factor 2 Weight	h^2 (%)
12	**0.74**	1.63	0.15	0.15	56.9
6	**0.70**	1.36	0.15	0.15	50.9
3	**0.64**	1.10	0.31	0.34	50.9
11	**0.61**	0.97	0.08	0.08	37.8
4	**0.54**	0.76	**0.50**	0.66	53.8
5	**0.43**	0.54	0.34	0.38	30.3
10	0.39	0.45	0.03	0.03	15.0
1	0.23	0.25	0.06	0.06	5.8
9	0.17	0.18	**0.88**	4.02	81.0
8	0.24	0.25	**0.71**	1.44	56.2
2	0.29	0.31	**0.63**	1.03	47.6
7	**0.47**	0.60	**-0.60**	0.95	58.0
% Variance Explained	24		21		

* Respondents are grouped by factor and organized from highest to lowest loading, with shading indicating each grouped factor. Respondent 1 did not significantly load onto either Factor 1 or Factor 2, and was thus excluded from continued analysis. Significant rotated factor loadings are bold. Recall that communalities are denoted as h^2, and are calculated as the sum of squared factor loadings (Brown, 1980). Expressed as a percentage, communalities (h^2) represent how much an individual Q-sort holds in common with all of the other Q-sorts in the study; the higher the communality, the higher the individual Q-sort represents the factor group.

The rotated factor matrix displays several concerns to address. First, Respondent 1 did not load significantly onto either Factor 1 or Factor 2; thus Respondent 1 is described as a **null loader** (Scott et al., 2014), did not make the cutoff for significance into either factor, and was not captured in the model. Ultimately, it was better to exclude this respondent than force them into a specific factor because it would dilute the viewpoint (D. Hensel, personal communication, February 12, 2018). Note that this particular resident was part of the class of 2017 and received two years of HFPS in the IUBIPSC. This finding may indicate that given a larger sample of respondents, there is another factor yet to be discovered. Respondent 1 declined to be interviewed; however,

their open-response comments alluded to a general negative viewpoint of HFPS, an ineffective outlook towards IPE, feelings of predictability experienced during the HFPS scenarios, and difficulty not only believing the manikin was a real patient, but also being unable to take the simulation seriously because they could not harm the patient manikin.

[MR-01]: "It is just difficult for me to believe that a manikin is a real patient especially when you know that nothing you do will actually harm the "patient." They're also creepy and that throws me off big time. The simulations were predictable because of the classic, clear-cut scenarios that were given to us. 57-year-old white male with chest pain and diaphoresis with a history of angina. Pretty predictable that it was an MI. When I was in the sim center with the nursing students they were the ones who led the show because they actually knew how to work a hospital room, meanwhile I was just standing there with no clue how to use oxygen or put on a nasal cannula right. Sim training can't replace real world experience because once again, you know you can't harm the manikin. If it was a real patient it would be twice as challenging because you know that this is the real deal."

Second, Factor 2 is considered a **bipolar factor**, indicating that both positive and negative rotated factor loadings were observed with the respondents loading onto this factor. Notice that all rotated factor loadings are positive except for Respondent 7. This individual strongly loaded onto Factor 2; however, this respondent had a negative correlation denoting an opposite viewpoint from the rest of the participants grouped into Factor 2. The Ken-Q Analysis© program used for this factor analysis allowed for splitting of the bipolar factor into two subfactors (Factor 2a and Factor 2b).

Third, Respondent 7 is significantly loaded onto both Factor 1 and Factor 2. Q-sorts that load significantly on two or more factors are known as **confounded Q-sorts** (commonly referred to as 'cross-loadings' in factor analysis) and are usually excluded

from the rest of the analysis. However, Watts and Stenner (2005) recommended a strategy of raising the significance threshold level (i.e., making the statistical criterion more stringent) in order to minimize the number of confounded Q-sorts but maximize the number of significant Q-sorts. If this procedure is performed on the rotated factor matrix in this study, the significance level should be set to ±0.48, forcing Respondent 7 off of Factor 1 and onto the bipolar Factor 2. However, in doing so, the significance of Respondent 5 of Factor 1 is lost. Additionally, a standard requirement is having at least two significantly loading Q-sorts (known as 'factor exemplars') on a factor (Watts & Stenner, 2005); therefore Factor 2b consisting of one medical resident (Respondent 7) violates this standard requirement. However, most of the Q-methodology community generally finds it acceptable to have a factor consisting of one person, if that individual is part of a bipolar factor (D. Hensel, personal communication, June 8, 2018).

The last issue in the rotated factor matrix is seen with Respondent 10. While Respondent 10 did load onto Factor 1, it was not significant, and typically only qualitative comments are incorporated into factor interpretation from significantly loading participants (Watts & Stenner, 2005).

While acknowledging the recommendations from Watts and Stenner (2005), for the purposes of exploring Respondent 7's viewpoint compared to the other medical residents' viewpoints in this study, interpretation of Factor 2b continued. Therefore, after factor extraction and subsequent rotation, one unipolar factor (Factor 1) and one bipolar factor (Factor 2a and Factor 2b) were obtained, resulting in three factors for the final factor solution that explained 45% of the total variance in the data.

Step 4. Compute factor weights and factor scores.

Factor weights (Table 7.5) were calculated using the following formula: $w = f /$

$(1\text{-}f^{2})$ where w is the factor weight and f is the factor loading. From the merger of the

factor weights, factor loadings, and sorted statement (performed by Ken-Q Analysis©),

the idealized Q-sort was created for each factor (Table 7.6). Recall that the idealized Q-

sort specifies which statements characterize each factor for all participants grouped into

the same factor. The factor scores of the idealized Q-sort were computed as the weighted

averages of the statement rankings of each participant within the factor and then

normalized to allow comparisons across factors.

Table 7.6: Complete list of the 37 Q-sort statements and the idealized Q-sorts for the
patterns representing medical residents' viewpoints of HFPS experienced
during their medical education

	Factor 1: Practical Skeptics	Factor 2a: Simulation Enthusiasts	Factor 2b: Anxious Supporter
1. I think simulations should be used for teaching rather than for evaluating my performance	0	+1	+1
2. Participating in simulations made me feel more confident	+1	**+3[a]**	0
3. Simulations were less helpful because of the anxiety that they created	−3	−2	**+1[a]**
4. Simulations gave me a chance to practically apply knowledge learned in class	+3	+4	**0[a]**
5. It was difficult to believe that a manikin was a real patient	+2	**−3[a]**	+3
6. I was able to easily transfer what I learned during simulations to real clinical settings	−2	**+2[a]**	−1
7. Participating in simulations prepared me to work independently	0	0	**−4[a]**
8. Simulations were predictable	−3	−4	**+2[a]**
9. Participating in simulations improved my critical thinking skills	+1	+3	+1
10. Simulation-based training can replace	−4	−3	−4

clinical experience in the real world			
11. The IPE simulations with the nursing students helped me learn how to work in a multidisciplinary team	**0ᵃ**	**+4ᵃ**	**−3ᵃ**
12. Simulations were better for reviewing material rather than learning new material	**0ᵇ**	+2	+3
13. I could not concentrate during simulations because I was conscious of being recorded	−3	−2	**+1ᵃ**
14. Simulations exposed me to diverse patient scenarios	+1	0	**−3ᵃ**
15. Simulation training improves patient safety	0	**+2ᵃ**	−2
16. Simulations helped me learn to think quickly under pressure	**+1ᵇ**	**+3ᵃ**	**−1ᵇ**
17. Simulations improved my communication skills with other healthcare providers	0	**+2ᵃ**	−1
18. The immersive, hands-on simulation environment is worth the expense to build and maintain	+3	**+1ᵃ**	+4
19. It was difficult to learn during simulations	−4	−4	**+1ᵃ**
20. Simulations are effective because residents learn by doing	**+4ᵃ**	+1	0
21. Participating in simulations prepared me to concentrate in a hectic clinical environment	0	**+1ᵇ**	−1
22. Simulations allowed me to practice how clinical skills are performed	−1	0	−1
23. It was difficult to relate the simulations to reality	−2	−2	**+2ᵃ**
24. The practice during simulations decreased my anxiety when helping real patients	**−1ᵇ**	**+1ᵇ**	**−3ᵇ**
25. I preferred training with interactive manikins (simulators) rather than Standardized Patients (SPs)	**+2ᵇ**	**−3ᵃ**	**+4ᵇ**
26. Simulations increased my awareness of my actual ability	+1	0	0
27. The debrief after simulations is the most important component of a simulation-based learning experience	−1	**+1ᵇ**	−2
28. Simulations should be used beginning in the first year of medical school	+3	**0ᵇ**	+2
29. Participating in simulations helped me learn from my mistakes	**+2ᵇ**	0	0
30. Simulations prepared me to recognize emergency (life-threatening) situations	−1	0	−2

31. Simulations were stressful because it felt as though I was on a stage	–2	–2	**+1**[b]
32. Physically interacting with the environment in the simulation center helped me remember things better	–1	–1	0
33. Participating in simulations helped me develop my routine	–1	–1	–2
34. Simulations improved my communication skills with patients	–2	–1	–1
35. More simulations should have been offered during my medical education	+2	**–1**[a]	+2
36. Effective simulations require a well-trained operator/coordinator	**+4**	**–1**[a]	+3
37. Simulations created a fun environment to learn	+1	–1	0

The numbers ranging from –4 to +4 correspond to the location of the statements in an idealized Q-sort representing each pattern, placed in a quasi-normal distribution grid (see Figure 3.6). Distinguishing statements for each pattern are bold.
[a] Distinguishing statements p ≤ .01
[b] Distinguishing statements p ≤ .05

The idealized Q-sorts also present the distinguishing statements between factors, the consensus statements across factors, and characterizing statements within factors. Recall that distinguishing statements are significantly distinct for a factor compared to another factor, consensus statements do not significantly differ for any factor, and characterizing statements are specific statements placed in the two columns of the polar extremes (+4 and –4) of the Q-sort grid. The distinguishing statements are indicated in bold in Table 7.6, the consensus statements are seen in Table 7.7, and the characterizing statements are indicated by +4 (strongly agree) and –4 (strongly disagree) in Table 7.6.

Table 7.7: List of consensus statements (i.e., the statements that do not significantly differ for any factor)

1:	I think simulations should be used for teaching rather than for evaluating my performance
9:	Participating in simulations improved my critical thinking skills
10:	Simulation-based training can replace clinical experience in the real world
22:	Simulations allowed me to practice how clinical skills are performed
26:	Simulations increased my awareness of my actual ability
30:	Simulations prepared me to recognize emergency (life-threatening) situations
32:	Physically interacting with the environment in the simulation center helped me remember things better
33:	Participating in simulations helped me develop my routine
34:	Simulations improved my communication skills with patients

Based on the consensus statements, all medical residents strongly disagreed that simulation could replace training in the real world training (statement 10). As exemplified by one medical resident, "As effective as simulation is, nothing can fully replace clinical experience in the real world. [HFPS] should be used as a supplement to real-world clinical experience" (MR-09). The medical residents did agree that participating in simulations improved their critical thinking skills (statement 9), but unanimously disagreed that participating in simulations helped them to develop their routine (statement 33) or prepared them to recognize emergency (life-threatening) situations (statement 30). They also disagreed that simulation improved their communication skills with patients (statement 34), as illustrated in the following quote, "Simulation patients do not behave like real world patients and should not be used for evaluation or replacement of real world experience" (MR-06).

The residents in this study slightly agreed that simulations should be used for teaching rather than for evaluating their performance (statement 1), as noted by MR-11:

"I thought that we should have more simulations in medical school and I thought [simulations were better for reviewing] what you had learned rather than learn new things." The residents also slightly agreed that participating in simulations helped to increase their awareness of their actual ability (statement 26), "It was not difficult to learn during simulations, in fact, I remember well my simulations that were 3 years ago and the debrief's rapid feedback solidified everything" (MR-05). Slight disagreement came from statement 22, that simulations allowed them to practice how clinical skills were performed (MR-11: "I didn't think we practiced any clinical skills or procedures and it was often difficult to do a physical exam"). Lastly, the residents slightly disagreed that physically interacting with the simulation environment helped them to remember things better (statement 32), although one resident noted that, "The operator makes a huge difference" (MR-03). Note that distinguishing and characterizing statements will be discussed with each individual factor in the next section.

Factor interpretation is not only influenced by the physically placed statements within the Q-sort represented by the factors and the open-response comments, but is also supplemented with post-sort interviews conducted with the participants to support the quantitative findings and further elucidate the results (Berkhout et al., 2017). For this research, all medical residents who indicated "Yes" on the final dichotomous question presented after the sorting phase (see Figure 7.6), were contacted for a phone or Skype interview at their convenience (Table 7.1). Six residents indicated they would be willing to interview; however, due to scheduling conflicts, ultimately one medical resident was interviewed (Table 7.1). This resident's comments are incorporated into Factor 2a, the factor that they were grouped within, and presented in the Discussion section.

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The following section provides a description of the factor interpretation for the three factors with statements and their corresponding ranking from the idealized Q-sort (Table 7.6).

Step 5. Interpret the factors.

The final step of the Q-methodology procedure involves the interpretation of the three factors based on the idealized Q-sort, distinguishing statements, consensus statements, characterizing statements, analysis of the open-response items from the Q-sort, and the interview with one medical resident. The analysis described below eventually led to labels and explanations created by the author for each factor, and included: **Factor 1: Practical Skeptics**; **Factor 2a: Simulation Enthusiasts**; and **Factor 2b: Anxious Supporter**. Each factor will now be described.

Factor 1: Practical Skeptics

The respondents grouped into **Factor 1** were entitled **Practical Skeptics**, by the author and was defined by the Q-sorts of seven medical residents (see Table 7.6). One medical resident was from the class of 2015, one resident was from the class of 2016, and five residents were from the class of 2017. This factor explained 24% of the total study variance. Individuals grouped within Factor 1 represented a similar pattern of finding value in the pragmatic relevance of the simulations, but had difficulty suspending their disbelief at times and did not readily see the applicability of this intervention to their healthcare team mentality.

Medical residents within this factor agreed that simulations allowed them to

practically apply theoretical classroom knowledge (statement 4, +3). Because the residents within this factor believed that they learn by doing (statement 20, +4) and learn from their mistakes (statement 29, +2), they viewed the experiential environment of the simulation center as worth the expense to construct (statement 18, +3) and should be operated by a skilled simulation operator (statement 36, +4). They did not find the simulations predictable (statement 8, -3), and agreed that simulations should be incorporated into the first-year medical curriculum (statement 28, +3). The respondents within this factor also concurred that more simulations should have been offered during their medical education (statement 35, +2).

However, the medical residents in Factor 1 generally found it difficult to believe the simulation manikin was a real patient (statement 5, +2), and found it difficult to transfer their simulated knowledge to real-life situations (statement 6, –2; statement 21, 0). Although finding it difficult to envision the manikin as a patient, those medical residents grouped into Factor 1 did prefer preparation with the manikin to a trained actor (statement 25, +2), known as a Standardized Patient (SP). They did not necessarily feel stress or anxiety during simulations that prohibited them from learning (statement 3, –3; statement 13, –3; statement 19, –4; statement 31, –2), but also did not derive much confidence from participating in simulations (statement 2, +1; statement 24, –1), and only slightly agreed that the simulations helped them learn how to think quickly under pressure (statement 16, +1), exposed them to diverse patient scenarios (statement 14, +1), and was a fun environment to learn (statement 37, +1). They did not have trouble relating the simulation to reality (statement 23, –2), but were undecided as to whether simulation actually improves patient safety (statement 15, 0).

Surprisingly and contrary to the literature (Henneman et al., 2007; Landeen et al., 2015; Shinnick, Woo, Horwich, & Steadman, 2010), the debrief following the simulation event was not perceived as the most important component of the simulation-based learning experience to these medical residents (statement 27, –1). This response may have been due to a number of factors which affected the debriefs at IUSM-B, and will be explored in the Discussion section of this chapter. There were also several undecided statements among the medical residents in this group, including: whether simulations were better for reviewing material rather than learning new material (statement 12, 0), if participating in simulations prepared them to work independently (statement 7, 0), or if they found the IPE simulations particularly valuable for working and communicating as a healthcare team with the nursing students (statement 11, 0; statement 17, 0).

Recall that after the Q-sort procedure, participants were directed to a screen enabling them to comment on the reasoning behind the two highest (+4) and two lowest (–4) ranked statements (see Figure 7.5). Narrative data from the open-response comments aided in confirmation of the statistical interpretations of this factor. Note that phone interviews could not be conducted with those medical residents grouped into Factor 1.

[MR-04]:   "I drew from my experience with simulations when needing to think under pressure and I know my clinical skills are better for having been trained using simulations. Further, Bloomington students have a reputation for performing better clinically and this has been attributed to our extensive involvement with simulations in our first two years."

[MR-05]:   "During the simulations I had to think and act for myself and I could do that because it was a no-risk situation, but there simply is no replacing real world experience. You can try to suspend disbelief but it's always going to be there that it is a machine laying on the bed."

[MR-12]:   "Simulations were actually a really well done part of medical school at IU and I'm glad I could be a part of them."

Factor 2a: Simulation Enthusiasts

The respondents grouped into **Factor 2a**, entitled **Simulation Enthusiasts**, included the Q-sorts of three medical residents. One medical resident was from the class of 2015, while the other two medical residents were from the class of 2017. This factor (combined with Factor 2b, described in the next section) explained 21% of the total study variance. Individuals grouped within Factor 2a demonstrated a pattern of embracing the simulation experience, did not have much difficulty overcoming the believability of the simulated environment or manikin, and found value working with the nursing students during IPE simulations.

Several similarities were observed between those in Factor 1 and Factor 2a. For instance, similar to the medical residents in Factor 1, those medical residents in Factor 2a also agreed that the simulations gave them a chance to practically apply basic science knowledge (statement 4, +4), did not find it difficult to learn from simulations (statement 19, –4) or relate simulations to reality (statement 23, –2), did not feel overwhelming anxiety or stress (statement 3, –2; statement 31, –2) prohibiting them from concentrating during the simulations (statement 13, –2), and did not find the simulations to be predictable (statement 8, –4). Like Factor 1, those grouped into Factor 2a were also undecided as to whether participating in simulations prepared them to work independently (statement 7, 0).

However, there were several contrasting beliefs between those grouped into Factor 2a compared to those in Factor 1. Unlike Factor 1, those in Factor 2a generally did not have difficulties believing that the manikin was a real patient (statement 5, –3) and believed that simulation training improves patient safety (statement 15, +2), but less strongly agreed that simulations are effective because residents learn by doing (statement 20, +1). While those in Factor 1 were undecided about whether simulations were better for reviewing material rather than learning new material, those in Factor 2a agreed with this statement (statement 12, +2), and more strongly agreed that participating in simulations prepared them to concentrate in a hectic clinical environment (statement 21, +1), and believed that the practice that they obtained during simulations decreased their anxiety while working with real patients (statement 24, +1).

Also unlike those in Factor 1, Factor 2a found it easier to transfer knowledge obtained in the simulation to real clinical settings (statement 6, +2), more strongly agreed that participating in simulations made them feel confident (statement 2, +3), and more strongly agreed that simulations helped them learn how to think quickly under pressure (statement 16, +3). Those in Factor 2a also had a more positive viewpoint regarding IPE simulations, strongly agreeing that the IPE simulations with the nursing students helped them learn how to work as a healthcare team (statement 11, +4) and learn how to communicate (statement 17, +2).

In contrast to the support that Factor 1 held to begin simulations in the first-year of medical school, those in Factor 2a were undecided (statement 28, 0). Medical residents in Factor 2a were also undecided as to whether participating in simulations helped them learn from their mistakes (statement 29, 0) or expose them to diverse patient scenarios

(statement 14, 0), slightly disagreed that more simulations should have been offered during their medical education (statement 35, –1), and slightly disagreed that simulations created a fun environment to learn (statement 37, –1). Those in Factor 2a less strongly agreed that the immersive, hands-on environment was worth the expense to build and maintain (statement 18, +1) by a skilled simulation operator (statement 36, –1).

Another contrast between the two factors revolved around their preference for SPs; those in Factor 1 agreed that they preferred training with simulators over SPs, while those in Factor 2a strongly disagreed with the statement 'I preferred training with interactive manikins (simulators) rather than Standardized Patients (SPs)' (statement 25, –3). The complex opinions and varied experiences with SPs at IUSM were noted in the medical student interviews (see Chapter 6) as well. An explanation as to why those grouped into Factor 2a were decidedly classified as "Simulation Enthusiasts," yet appeared to prefer using SPs to working with simulators is explored in the Discussion section of this chapter.

Yet another contrast was found in the debrief; those in Factor 1 slightly disagreed that the debrief after simulations was the most important component of the simulation experience, whereas those in Factor 2a only slightly agreed (statement 27, +1). Although medical residents of Factor 2a slightly agreed, it is again surprising that the debrief was not more highly regarded since this finding differs from that in the literature (Henneman et al., 2007; Landeen et al., 2015; Shinnick et al., 2010). Possible reasons for why the medical residents in this study did not more highly value the debrief is elucidated in the Discussion section.

Again, the narrative data obtained from the open-response comments at the end of

the Q-sort procedure of those medical residents grouped into Factor 2a highlighted the

conclusions drawn from the statistical analysis. Additionally, one interview was

conducted with a medical resident from the class of 2015 that was grouped into this

factor (see Table 7.1), which also aided in factor interpretation.

[MR-02]: "During a code, communication is of utmost importance and the simulations prepared me for that as well as made me feel more confident as I had already run through the code algorithm."

[MR-08]: "Debriefing ties everything together. Learning can't happen without feedback. The hectic scenario of simulation helps prepare you for clinical rotations. Simulations were never predictable. I learned more from 30 minutes of simulation than I would from reading a text."

[MR-09]: "I found one of the greatest challenges in medicine was relating my book knowledge to a clinical setting. Simulation allowed a safe and effective environment to do so. Learning to work as part of a multidisciplinary team is something very difficult, if not impossible, to teach with books. This is something that must be learned by doing. Simulation allowed me to communicate with the nurses and other team members without there being risk of harming real patients."

Factor 2b: Anxious Supporter

As previously described, Respondent 7 significantly loaded onto Factor 2;

however, the negative correlation of this factor indicated that this particular medical

resident held an opposing viewpoint to the rest of those grouped into Factor 2.

Respondent 7 was from the class of 2017 (thus had two full years of HFPS in the

IUBIPSC). This factor, **Factor 2b**, was labeled **Anxious Supporter**, because Respondent

7 embraced the use of HFPS in medical education, but failed to see the transferability to

real clinical settings and did not regard IPE favorably as seen with Factor 2a. Factor 2b

also captured the stress and anxiety that some experience while participating in a high-fidelity clinical environment that was not seen with the other two factors.

There were several direct contrasts between Factor 2a and Factor 2b alluding to the bipolar nature of this factor. While those in Factor 2a strongly agreed that simulations gave them a chance to practically apply classroom knowledge, Respondent 7 of Factor 2b was indifferent (statement 4, 0). Factor 2a respondents did not find it difficult to believe that the manikin was a real patient; however, the Factor 2b respondent did struggle with this concept (statement 5, +3). Factor 2a respondents believed that they could easily transfer what they learned during simulations to real clinical settings, whereas Factor 2b disagreed (statement 6, –1; statement 23, +2) and did not believe that the simulations decreased their anxiety while working with real patients (statement 24, –3). Also, those in Factor 2a slightly agreed that the debrief was the most important aspect of HFPS, while Factor 2b disagreed (statement 27, –2).

While those in Factor 2a felt confident after participating in simulations, Respondent 7 of Factor 2b was indifferent (statement 2, 0). Respondent 7 also agreed that the simulations were predictable (statement 8, +2), did not find working with the nurses during IPE simulations helpful for learning how to work (statement 11, –3) or communicate (statement 17, –1) as a multidisciplinary healthcare team, and disagreed that simulation training improves patient safety (statement 15, –2), which are all in contrast to that seen in Factor 2a. Likewise, Factor 2b disagreed that simulations were helpful for learning to concentrate in a hectic clinical environment (statement 21, –1) or learn to think quickly under pressure (statement 16, –1), and was undecided as to whether

simulations created a fun environment to learn (statement 37, 0), opinions that differed from Factor 2a.

Both Factor 1 and Factor 2a respondents were undecided as to whether participating in simulations prepared them to work independently; however, Factor 2b strongly disagreed with this idea (statement 7, –4). While those in both Factor 1 and Factor 2a strongly agreed or agreed that participating in simulations was effective because residents learn by doing, Factor 2b was undecided (statement 20, 0). Also, while those in both Factor 1 and Factor 2a agreed that the immersive simulation environment was worth the expense to build, Factor 2b more strongly agreed (statement 18, +4). Another stark contrast between Factor 2a and Factor 2b respondents resided in the viewpoint of SPs. While Factor 2a preferred training with SPs to training with simulators, Factor 2b strongly agreed that they preferred the manikins to working with SPs (statement 25, +4).

Factor 2b more strongly believed that simulations should be incorporated into the first year of medical school (statement 28, +2), believed that more simulations should have been offered during their medical curriculum (statement 35, +2), and that effective simulations require a well-trained simulation operator (statement 36, +3). Also, Factor 2b agreed that simulations are better for reviewing material rather than learning new material (statement 12, +3) and disagreed that simulations exposed medical students to diverse patient scenarios (statement 14, –3).

Factor 2b expressed more anxiety and nervousness in the simulations than those in both Factor 1 and Factor 2a. For instance, Respondent 7 of Factor 2b found it difficult to concentrate during the simulations due to the anxiety that they created (statement 3,

+1) knowing that they were being watched and recorded (statement 13, +1), and found it difficult to learn during the simulations (statement 19, +1) because it felt as though they were on a stage (statement 31, +1). Some HFPS literature has confirmed the feelings that this particular medical resident felt as they participated in the IUBIPSC. Instances of anxiety (Lasater, 2005, 2007; Landeen et al., 2015), stress (Baxter et al., 2009; Harvey et al., 2010; Lasater, 2007), and the feeling of being on a stage (Yeun et al., 2014) have been reported.

Unfortunately, Respondent 7 declined a request to interview. The open-response comments from the last step of the Q-sort process were also brief from this medical resident; when asked to explain the reasoning behind the highest (+4) ranked statements (statement 18: The immersive, hands-on simulation environment is worth the expense to build and maintain, and statement 25: I preferred training with interactive manikins (simulators) rather than Standardized Patients), Respondent 7 noted the following:

[MR-07]:   "It allows for screw-ups while standardizing the
             encounter."

Next, while discussing the reasoning behind the lowest (–4) ranked items (statement 7: Participating in simulations prepared me to work independently, and statement 10: Simulation-based training can replace clinical experience in the real world), Respondent 7 explained:

[MR-07]:   "Real world experience is a necessity and real world
             encounters allow for independent work."

Discussion

Q-methodology has been described as a robust exploratory research technique to discover shared meaning, or key 'viewpoints,' held in common within a particular group, and is visualized through the extraction of factors based on Q-sort patterns (Watts & Stenner, 2012). Guided by Research Question 3b (asking "How do medical residents perceive the utility of, and satisfaction with, HFPS experienced during their medical education?"), the goal of this research was to discover patterns of IUSM medical graduates' perceptions regarding HFPS, and what the most important characteristics of these patterns are in order to illuminate the utility of simulation in medical education. Understanding the viewpoints of recent IUSM medical graduates who experienced HFPS during their medical education may aid in identifying how future performance is augmented based on exposure to this instructional adjunct, how they believe simulation is applicable to their current careers, and will ensure that HFPS is meeting "the unique learning needs of the student population" (Baxter et al., 2009, p. 865).

Similar to that stated in Berkhout et al., (2017), the main strength of this study resides in the Q-set composed of statements obtained from interviews with medical students (see Chapter 4), faculty, and staff as well as the extensive literature review of simulation and Q-methodology (see Chapter 2). The authenticity of these statements aid in, "facilitating recognition by participants" (Berkhout et al., 2017, p. 118), and supports generalizability of the study findings. Recruitment of several different perspectives of medical graduates across the United States, from residencies in internal medicine, emergency medicine, obstetrics and gynecology, and surgery is another strength of this

study. This recruitment facilitated more comprehensive findings of relevant perceptions regarding HFPS utilized in medical education.

A three-factor solution was found to be the most comprehensive interpretation of the Q-sort data for this research. The three factors accounted for 45% of the total variance and 11 participants (91.7%) mapped onto one of the three factors. Recall that one participant did not load significantly onto any one factor and thus was removed from further analysis. Although a two-factor solution was indicated from the eigenvalues and scree plot, the second factor was considered a bipolar factor, and thus was split to account for the significant, but opposite, viewpoint of Respondent 7 (Watts & Stenner, 2012). The three factors were described as: Factor 1: Practical Skeptics, Factor 2a: Simulation Enthusiasts, and Factor 2b: Anxious Supporter. These categorical labels were derived by the author based on the data obtained from the Q-sorts submitted by the participants. Although segregated into different factors, the participants in this study shared many opinions regarding HFPS.

One of the greatest surprises encountered in this study revolved around the debrief session that immediately follows HFPS. The debrief is proclaimed as being the most beneficial aspect of HFPS efficacy (Henneman et al., 2007; Issenberg et al., 2005; Landeen et al., 2015; Shinnick et al., 2010), and was viewed as very important by most medical students from the study in Chapter 6. However, the idealized Q-sorts revealed that the debrief was not deemed as the most important element of the HFPS experience to the medical residents in this study (statement 27: −1 for Factor 1; +1 for Factor 2a; and −2 for Factor 2b).

Although a debriefing session following a HFPS event is standard practice, the effectiveness of the debrief may simply be assumed as there is little tangible evidence to support its effectiveness (Levett-Jones & Lapkin, 2012). Even some current second-year medical students at the time of this study interviewed in Chapter 6 noted elements of either the ineffective flow of conversation during the debrief (MS2-13: "Sometimes [the debriefs] were a little rambly") or inadequate time devoted to the debrief (MS1-02: "…debriefings, if they could be a little bit longer that would be great"). However, while a few instances of criticisms regarding the debrief appeared among the medical students in Chapter 6, they were outweighed by perceptions that the debrief was immensely important to learn from mistakes, acknowledge accomplishments, and capitalize on the opportunity to acquire knowledge from an experienced physician. Taken together, this finding may allude to the dedicated training and practice required to cultivate debriefing skills over time.

Several models for successfully conducting effective debriefs exist, such as "The Diamond Debriefing Method" (Jaye, Thomas, & Reedy, 2015), "SHARP: 5-step Feedback Tool" (Ahmed et al., 2013), "Plus Delta (+/Δ) Method" (Fanning & Gaba, 2007), and "The Jeffries Method" used within the IUBIPSC (S. Gindling, personal communication, June 7, 2018), among many others. Methods are articulated and the importance of providing feedback is abundant; however, there is an apparent gap in the literature pertaining to the rigorous inquiry-based evaluation for best practices of guiding a post-HFPS debrief, with the majority of reports rooted in simple observation or trail-and-error studies (Dreifuerst & Decker, 2012). More substantial evaluations into debriefing efficacy are needed to fully understand the impact that targeted feedback has

on learning outcomes.

The medical residents from all factors also agreed that participating in HFPS improved their critical thinking skills (statement 9, a consensus statement), which is a commonly held view in simulation literature (Akhtar-Danesh et al., 2009; Lasater, 2007; Lee et al., 2017; Weis & Guyton-Simmons, 1998). The medical residents were also generally supportive that simulations should be used for teaching rather than evaluating their performance (statement 1, a consensus statement). The realistic high-fidelity simulated environment may evoke psychological stress that interferes with judgment (Baxter et al., 2009; Harvey et al., 2010; Landeen et al., 2015; Yeun et al., 2014); therefore, it is not surprising that recent medical residents would prefer to learn from a simulation rather than be evaluated using this platform.

Medical residents in the study disagreed that HFPS helped them develop their routine (statement 33: –1 for Factor 1; –1 for Factor 2a; and –2 for Factor 2b). This finding may be due to the scripted nature of the simulation events (see Chapters 3, 6, and 8), and similar results have been published. For instance, in their Q-methodology study of 21 undergraduate nursing students, Landeen et al. (2015) labeled one of their factors "Support seekers," as those students who did not find simulation helpful with their organization skills.

The fidelity, or realism, conveyed during HFPS was also another area of consensus among the medical residents in this study. Medical residents disagreed that participating in simulations improved their communication skills with patients (statement 34, consensus statement: –2 for Factor 1; –1 for Factor 2a; and –1 for Factor 2b). Even though the patient manikin has voice capabilities through an embedded microphone,

certain elements of physical interaction are lacking, such as nuances of facial expression and physical gestures. This was also noted in the medical student portion of this research (Chapter 6), as well as in the literature (Grice et al., 2013; Luctkar-Flude et al., 2012; Wisborg et al., 2009). It is likely that with rapid advancements in simulation technology, this impediment to simulation believability will diminish.

The medical residents in this study also did not feel strongly that simulations helped them to recognize emergency (life-threatening) situations (statement 30, consensus statement: –1 for Factor 1; 0 for Factor 2a; –2 for Factor 2b), did not generally feel that simulations increased awareness of their actual ability (statement 26, consensus statement: +1 for Factor 1; 0 for Factor 2a; 0 for Factor 2b), and did not believe that HFPS allowed them to practice how clinical skills are performed (statement 22, consensus statement: –1 for Factor 1; 0 for Factor 2a; –1 for Factor 2b). These are slightly unexpected findings in contrast to much of the HFPS literature, which is awash with reports of simulation imparting practical skills and ability, such as auscultation (Jones et al., 1997; Zafar, 2016), intravenous access (Sica et al., 1999), laparoscopy training (Grantcharov et al., 2004), thoracentesis (Barsuk et al., 2017), and personal protective equipment (PPE) training (Zach, Maloney, Praslick, Wackett, & Seidman, 2016). Given this contradiction from the literature, it may be that the residents in this study did not clearly see the clinical skill building value of HFPS, which would indicate the faculty may need to be more explicit in discussing the skills and techniques they expect students to obtain after participating in HFPS.

While some similarities existed among the three factors, many differences were highlighted in this study. Similar to the dual positive and negative findings in the study of

medical students (see Chapter 6), the role of IPE and SPs also had conflicting results

among the medical residents in this study. Those in Factor 2a had a more positive

viewpoint regarding IPE simulations than either Factor 1 or Factor 2b. Those in Factor 2a

strongly agreed that the IPE simulations with the nursing students helped them learn how

to work in a multidisciplinary team (statement 11, characterizing statement, +4) and

agreed that simulations helped them learn how to communicate with other healthcare

providers (statement 17, +2). In contrast, Factor 1 was neutral with respect to the

importance of IPE simulations for learning how to work in a multidisciplinary team

(statement 11, 0) or for building communication skills with other healthcare providers

(statement 17, 0). Factor 2b on the other hand, disagreed that the IPE simulations with the

nursing students helped them learn how to work in a multidisciplinary team (statement

11, –3) or communicate with other healthcare providers (statement 17, –3).

The negativity surrounding IPE training was most notably captured in Respondent

1, who did not significantly load onto any factor and was excluded from the analysis.

Recall that Respondent 1 conveyed a general negative disposition to IPE in their open

response comments, describing various difficulties collaborating with the nursing

students who were more knowledgeable regarding the basics of functioning in a hospital

room.

IPE is now foundational to healthcare sciences to establish cohesive and holistic

teams early in training for efficient and effective patient care. Most studies report positive

interactions and healthy team dynamics among student IPE teams (Feather et al., 2016;

Herrmann et al., 2015; Reising et al., 2011; Wong et al., 2016). A few studies do exist

that discuss the challenges of IPE, including the need for clear articulation of learning

goals (McBride & Drake, 2015) and negative comments and poor ratings of quality interactions (Niekrash et al., 2015). IPE is a widely utilized pedagogy used with medical and nursing students (Feather et al., 2016; Herrmann et al., 2015; Reising et al., 2011), medical students and physician assistant students (McBride & Drake, 2015), nursing students and resident physicians (Wong et al., 2016), and dental students, medical students, and pathology assistant students (Niekrash et al., 2015); therefore, understanding the various dynamics that can surface while students participate in multidisciplinary teams is an important avenue of future research (see Chapter 8).

Another contrasting viewpoint between the factors revolved around the medical residents' preference for SPs; those in Factor 1 preferred training with simulators over SPs (statement 25, +2), Factor 2a preferred SPs over simulators (statement 25, –3), and Factor 2b strongly preferred the simulators to working with SPs (statement 25, +4). The complex opinions regarding SPs were also noted in the medical student interviews (see Chapter 6), and reported in several studies noting positive SP perceptions (Grice et al., 2013; Luctkar-Flude et al., 2011; Wisborg et al., 2009) as well as frustrations with SPs (Bokken et al., 2010; Collins & Harden, 1998; Dotger et al., 2010; Steinman, 2014); see Chapter 6 for more detailed information regarding these studies.

Scrutiny of the specific statement rankings, such as the SP statement just described, in relation to the categorical label assigned to each factor (Factor 1: Practical Skeptics; Factor 2a: Simulation Enthusiasts; and Factor 2b: Anxious Supporter) will observe conflicting data in relation to the assigned label. For instance, Factor 2a was labeled Simulation Enthusiasts given the high ratings of IPE during HFPS (+4), feelings of being able to practically apply theoretical knowledge while participating in HFPS (+4),

belief that HFPS gave them confidence (+3), improved their critical thinking skills (+3),

and helped them learn how to think quickly under pressure (+3). Even their strongly

disagree (–4) characterizing statements translated to a general positive outlook in support

of HFPS, such as they did not find it difficult to learn from simulation (–4), did not find

simulation to be predictable (–4), did not find it difficult to believe the manikin as a

patient (–3), did not find simulations stressful (–2), anxiety-producing (–2), or found it

difficult to concentrate during HFPS (–2). These ratings were supplemented with

qualitative narratives from open response comments and the single interview that was

conducted to generate an overall description of enthusiastic support for HFPS in medical

education.

Discrepancies arise when looking at statement 25, in which Factor 2a indicated

preferring training with SPs rather than simulators. One might think if they are

enthusiastic about HFPS, then they might prefer simulators to SPs. A possible

explanation may reside in the fact that even if a participant is enthusiastic about HFPS,

there are some aspects that they may not completely support. The participants in this

factor could still be excited about simulation, yet prefer SPs for the sheer fact that these

are two entirely different instructional strategies. For instance, from the analysis of the

ranking question of HFPS, SPs, real patients, part-task trainers, and computer-based

modules that medical students received in this dissertation research (see Chapter 6), it

was determined that it was difficult to rank order the choices because all of the modalities

are good for different learning outcomes. SPs are an entirely different education modality

than HFPS, which are excellent for building rapport with patients, practicing

communication with a human being, and performing a complete physical examination, so

the statement might have been an unfair comparison in the first place. In fact, a study of

44 nursing students found that even though the students performed significantly better on

focused respiratory assessments with HFPS, they preferred SPs because the humanistic

quality is lacking with a HFPS manikin (Luctkar-Flude et al., 2011). The medical resident

interviewed for this study confirmed this idea, by explaining that HFPS is an excellent

medium for learning emergency code situations and physical clinical tasks (such as chest

compressions), while SPs have their place as useful tools for physical examinations and

patient interactions.

> [MR-02]: "They are helpful for learning how to take care of
> patients…for a complete physical exam or a complete
> neurological exam, so I think they have their role in the
> non-acute care [setting]…they definitely have their
> usefulness there."

The forced distributed imposed by Q-methodology may have also affected the

interpretation of the factors as well. Using Factor 2a as an example again, it may not have

been that the medical residents grouped into this factor necessarily disagreed or where

neutral about certain statements, such as being neutral that simulations should be used

beginning in the first year of medical school (statement 28, 0), but rather a statement

could have represented a less important aspect of HFPS to them compared to the other

statements regarding HFPS. Even if participants in this study value many aspects of

HFPS, the forced distribution in Q-methodology requires that choices be made among

statements to bring to light what they truly value as the *most* important features about

HFPS. This hypothesis was confirmed during the interview with the medical resident

from Factor 2a describing the lack of the importance of the debrief, which was explained

at the beginning of this discussion.

> [MR-02]: "I definitely think [the debrief] is important. I guess I didn't
> feel it was as strongly important as it was going through the
> actual simulation itself. I think all education is learning
> what you did right and wrong, so the debrief session is a
> time to do that."

Additionally, respondent validation was included during the interview as

recommended by Watts and Stenner (2012). When this medical resident was asked

during the interview if they agreed that they would label themself as a "simulation

enthusiast," or if there was another label that they would attribute to their opinions

regarding HFPS in medical education, they confirmed that they would label themselves

as a simulation enthusiast and could see the value in using HFPS in medical education,

especially in the second year for IPE practice. The interviewee then went on to explain

that they continued to do HFPS in residency as well, approximately every two to three

months they participated in HFPS with about six other medical residents (for instance,

running through a code), but that they did not have extensive experience in their

residency working through HFPS with nurses or other healthcare providers during IPE

simulations. The role and implementation of IPE during residency could be an area for

future study.

Finally, although simulators are valuable learning tools, all medical residents

disagreed that simulation-based training can replace clinical experience in the real world

(statement 10, a consensus statement), and instead viewed simulation as a supplement to

clinical training. HFPS is a valuable learning experience and is becoming increasingly

more realistic (Bradley, 2006; Morgan et al., 2016; Sheakley et al., 2016), but literature supports the idea that HFPS can enhance, but will never completely replace the need for real world clinical experience (Baxter et al., 2009; Feingold, Calaluce, & Kallen, 2004; Landeen et al., 2015).

Limitations were associated with this portion of the dissertation research, clarified further in Chapter 8. According to previous Q-methodology authors, the sample size of 12 was adequate for this study. However, it is likely that the sample-size may have induced confounding factors into the present study since Respondent 1 did not load onto any factor and only one medical resident (Respondent 7) was grouped into Factor 2b. Given a larger sample, it is probable that more medical residents would have the same viewpoint as Respondent 1 and Respondent 7 in Factor 2b.

Lastly, an unexpected finding was discovered through the ease of the electronic Q-methodology study creation and study administration. Traditionally, Q-studies require participants to physically sort statements written on index cards onto a paper Q-sort grid at a large desk. Ha (2016) noted that one limitation in their Q-study was the study administration, which requires a period of orientation to the Q-sorting instructions, one to two hours per individual for the sorting process, and a quiet place with large tables. Block (1994) claimed that the administration of a 72-item Q-sort takes 20-25 minutes, which may appear excessive for some respondents. This dissertation research employed the use of electronic sorting software, known as Q-sortware (Pruneddu, 2011), which presented clear instructions, a step-by-step sorting procedure, and interactive click-and-drag functionality for ease of sorting. All medical residents completed the study in a reasonable amount of time; the average Q-study completion time was 11:02 minutes, and

ranged from 6:31 minutes to 18:56 minutes. While the electronic Q-sort was efficient, it also imposed an inherent limitation. The author only received confirmation of a completed Q-sort once the participant selected to submit their study on the final screen of the Q-sort software; therefore, it may be that other residents began the Q-methodology study but did not finish their sorting and decided to end their submission prematurely. The author has no way of verifying if this occurred in the present study.

The previous three chapters focused on the quantitative (Chapter 5) and qualitative (Chapters 6 and 7) impact of HFPS in medical education. Chapters 5 and 6 focused on medical students to investigate Research Questions 1, 2, and 3a; this chapter presented the qualitative results regarding the utility of HFPS for medical residents, addressing Research Question 3b. The next chapter will conclude the examination of this dissertation research, presents the overall conclusions drawn, and offers evidence-based recommendations as to the effective implementation of HFPS in medical education. Future directions for this research along with the inherent limitations encountered during this investigation will also be presented.

CHAPTER 8: CONCLUSIONS AND EVIDENCE-BASED RECOMMENDATIONS

FOR HIGH-FIDELITY PATIENT SIMULATION IN MEDICAL EDUCATION

High-fidelity patient simulation (HFPS) has become a widely used instructional intervention to impart learners, from undergraduates to professionals, with essential training. The previous chapters presented the quantitative and qualitative analyses of this dissertation research regarding the utility of, and satisfaction with, HFPS in medical education. Numerous studies were also presented from the literature that captured the significance, limitations, and controversies that surround HFPS in various healthcare populations. This final chapter will reexamine the salient results and draw conclusions for best practices when incorporating HFPS in medical education at IUSM-B, which could potentially extend to other medical simulation centers.

The first part of this chapter will present overall conclusions of this work, along with evidence-based recommendations regarding best practices for HFPS in medical education at IUSM-B. Given these recommendations, part two will present a proposed medical curriculum that strategically integrates HFPS throughout the first two years of medical school. Part three will acknowledge the limitations associated with this dissertation research and part four presents future directions that should be explored to further extend and continue guiding the methodical implementation of HFPS. Final conclusions will be drawn in part five to complete this work.

Part I: Conclusions and Evidence-based Recommendations for Best Practices in HFPS at IUSM-B

Given the existing literature (see Chapter 2) and the results of this dissertation research (see Chapters 4, 5, 6, and 7), best practices for how to effectively implement HFPS into medical curricula at IUSM were formulated. While these recommendations are unable to extend to the larger population of HFPS in all levels of medical education, Chen and Teherani (2016) explained that a potential outcome of a qualitative case study design is being able to generate recommended best practices for the particular case under study. Since this dissertation used a case study design of the IUBIPSC, evidence-based recommendations for an efficient and effective implementation strategy of HFPS in medical education at IUSM were developed.

The following recommendations of best practices for incorporating simulation as an educational intervention are grounded in this research. Generating a list of evidence-based recommendations for the future implementation of HFPS in medical education is imperative as this instructional adjunct has the potential to save human lives, which is confirmed in a statement made by Anderson, Aylor, and Leonard (2008), "human lives depend on the performance of our trainees; thus, the educational methodology used to transform our learners into experts are of paramount importance" (p. 595). This powerful statement embodies the essence of the simulation experience; therefore, the next section of this chapter uses an evidence-based lens to examine the incorporation of simulation into a modern medical curriculum. The following conclusions and recommendations will be discussed: 1. The experiential learning aspect of practicing in an immersive HFPS environment; 2. The role that HFPS has on the interprofessional education (IPE)

experience; 3. The need to formally integrate HFPS in the medical curriculum for continued practice with HFPS for students to acclimate to the environment and practice adjusting their strategies for future patient care; and 4. The impact that those actually running the simulation, the Simulation Coordinator in this research, has on the overall HFPS experience and the importance that initial, and continued, training in conducting the HFPS scenarios has on the delivery of high-quality HFPS experiences.

Note that in order to add to the interpretation of the conclusions and recommendations of this research, the Simulation Coordinator (who worked exclusively at the IUSM-B campus) and one nurse practitioner faculty member (who worked with all medical students within IUSM), were contacted for their perspectives regarding HFPS used as an educational adjunct in medical school. The qualitative interviewing supplements the conclusions and provides additional evidence to support the claims made in this section. Note that these additional interviews with the nurse practitioner faculty member (NP) and Simulation Coordinator (SC) were intended to supplement the interpretations; they were not conducted as part of the original research questions, and thus were not presented in the results chapters of this dissertation.

Conclusion 1: HFPS incorporates principles of Experiential Learning Theory (ELT) to provide immersive practice and reflection for medical students.

Recommendation 1: To fully obtain the benefits of ELT, HFPS should be implemented beginning in the first year of medical school.

HFPS provides a platform for learners to engage in experiential learning through physical practice and reflection. Medical students in this study (see Chapter 6) and the

faculty and staff interviewed for this chapter noted that the main benefit from HFPS is to

cultivate the psychomotor skills and thought-processes of a practicing physician and

embody the ability to think clinically in the IUBIPSC while engaging in practical

application of theoretical content knowledge from lectures.

[NP]: "…they actually get to think for themselves. That is a direct quote that I have heard…We get to put together what we've learned first and second year and nobody is telling us how to do it, so we learn by our mistakes…That is straight from the students' mouths."

[SC]: "Critical thinking, realistic immersion, it's unlike anything else…just the ability to practice all the stuff that they've gotten in lecture and their PBLs and TBLs…to teach themselves to calm down and handle the situation. We would much rather them do that here so that they have some sense of how to control that and critically think in a very intense situation, we want them to get practice doing that here before they do it in the real world."

While practicing in HFPS, the medical students learned their routine, the flow of

questions to construct a complete patient history, as well as the importance of non-verbal

communication like body language. Although the medical students in this study focused

on the physical act of communication through vocalization, simulations also aided them

in addressing non-verbal physical body language and facial expression. This

communication was noted in the interview with a nurse practitioner who explained that

HFPS provides an opportunity for medical students to learn how to assume an

appropriate "poker face" when breaking bad news to a patient.

[NP]: "I tell them, 'you guys need to learn poker faces, some of you in there during [the simulation] and you have to break some bad news, you can read it all over your face' and part of simulation is to learn not to do that."

The IUSM-B medical students became so well-trained that other IUSM faculty "could pick the Bloomington students out of the crowd" (NP). The IUSM-B medical students demonstrated competent behavior to the faculty members above that of their IUSM peers at the same medical level because they had already acquired skills, knowledge, and cultivated their clinical flow through the deliberate practice that they received within the IUBIPSC. Thus, as a result of participating in HFPS beginning in the first year of medical school, the IUSM-B students were adequately exposed to ELT and were well on their way to becoming competent physicians.

> [NP]: "[The IUSM-B medical] students just perform so much better in, and knowing that they, and they tell you 'Oh, yeah we had simulation year one, we had simulation year two,' and basically other than myself and ER, the ED department at the IU campus, gets simulation during third year, that's it. So if they don't get it first and second year at Bloomington, they're not getting it at all until they see a patient…so what do I get maybe, a couple of Bloomington students per every other session, so we're talking maybe one percent Bloomington students, so that means 99 probably never even set foot in a simulation room, and it shows… and the Bloomington students are usually done, I would say in about a ten minute scenario, in about seven minutes, they get all their questions, gather all their information really quickly…they include the correct differential in their top three. I can't say that about all the other students on the first day."

Finally, the ELT aspect was evident in this research. The realistic physical environment of the IUBIPSC provided authentic practice to medical students and the consistency of the manikins allowed all medical students to experience the same presentations. This consistency was not noted with all of the SP encounters in this research. Although "standardized" is in the name of the actors trained to portray patients, SPs may not be as standardized as intended. Some medical students that were interviewed

(see Chapter 6) and the nurse practitioner interviewed for this chapter (who is also a certified SP educator) commented that SPs were inconsistent at times, biased in their recommendations, and declined in quality presentation and feedback at the end of a long day of testing. In addition, the pilot study (see Chapter 4) discovered that some medical students found it easier to be compassionate and interactive with the manikins compared to SPs, because they knew the human actor was simply faking everything during their interactions.

The finding in this research of learners preferring simulators to SPs is in contrast to other studies. Third year pharmacy students preferred using SPs to a manikin even though there was no difference in physical assessment scores in the cardiac or pulmonary units (Grice et al., 2013). Among trauma teams in five Norwegian hospitals, Wisborg and colleagues (2009) found no significant difference in perceptions of realism between an SP or a manikin; however, the study participants preferred SPs when training for interacting as a team with a patient. In another study, 44 nursing students demonstrated significantly greater performance on focused respiratory assessments with HFPS, but they were less satisfied due to the lack of realism of the manikin (Luctkar-Flude et al., 2011). This research's contrasting findings to the literature may allude to specific issues with IUSM SPs or with the preferences of IUSM medical students; further studies are needed to confirm these hypotheses.

Unlike SPs, the patient manikin has the ability to display consistent and reliable presentations for all students throughout the duration of the day, and is more interactive than other forms of reliable computer-based technology. For example, in a randomized, counterbalanced repeated-measures design, Cendan and Johnson (2011) discovered that

their sample of 40 second-year medical students regarded manikin simulation training as more effective than an interactive web-based simulation program for learning shock during the cardiovascular unit of their medical physiology course. The simulation manikin was described as providing visual, tactile, as well as auditory manipulation that could not be afforded by the web-based application alone.

The realistic physical environment also allowed medical students in this dissertation research to practice managing psychological stress and performance anxiety while working in a realistic healthcare setting. This observation was also noted with 34 biomedical undergraduate students in a physiology course at the University of Central Florida College of Medicine, who explained that HFPS allowed them to review, integrate, and apply concepts in a real-world setting and physically perceive aspects from the classroom (Harris et al., 2014). The realistic environment was again noted in a study comparing HFPS to problem-based learning (PBL) among 31 fourth-year medical students. The authors concluded that HFPS was superior to PBL for the acquisition of critical assessment and management skills due to the primary difference of HFPS portraying a realistic patient environment (Steadman et al., 2006).

Even with the advanced manikin and realistic environment, some IUSM-B medical students explained that it was difficult to suspend their disbelief during HFPS (see Chapter 6). However, rapid advancements in technology may aid in assisting those medical students who struggled to believe the manikin was a real patient. Realistic robotics can emulate elements of physical interaction such as nuances of facial expression and physical gestures such as handshakes and the ability to sit upright and lie down; the pupils of more advanced manikins can trace students across the room, and a new birthing

simulator can simulate all stages of parturition, including the third stage with a realistic

placenta and umbilical cord (J. Hennings, personal communication, September 22, 2017).

Even with these technology enhancements, some learners may always have difficulty

suspending their disbelief because fundamentally HFPS is an imitation of reality. In these

instances, it is important to remind learners that they can still obtain valuable practice

from HFPS that could translate to real world settings.

Conclusion 2: HFPS can be used to support interprofessional education (IPE) in medical

education.

Recommendation 2: HFPS should be established in the first year of the medical

curriculum to develop healthcare team skills between medical and

nursing students.

HFPS was shown in this research to be an excellent medium for medical students

and nursing students to communicate as a healthcare team, learn their individual and

collective roles, and cultivate respect for fellow healthcare team members. HFPS has

already been shown to improve essential communication skills among IUSM-B medical

students and nursing students in interprofessional settings (Feather et al., 2016; Reising et

al., 2011). This dissertation research provides more evidence to support the claim that

HFPS aids in providing foundational teamwork and communication skills during the

formative years of medical education (Harris et al., 2014; Hunziker et al., 2010; Issenberg

et al., 2011; Scalese et al., 2007; Torres et al., 2014).

During qualitative interviewing with IUSM-B medical students (see Chapter 6),

almost all IUSM-B medical students claimed that the most beneficial aspect of

participating in HFPS was the realistic interactions that they participated in with their nursing students teams within the IUBIPSC. In fact, it appeared that only the IUSM-B medical and nursing students received quality IPE interactions within the first two years of training as all interviews from the control group noted infrequent IPE events that were ineffective at fostering adequate healthcare team dynamics. To investigate if early IPE interaction is influential in later stages of the medical curriculum, an IPE follow-up study in the third and fourth years could see if students exposed to HFPS have better communication and IPE skills than those who were not exposed to IPE, and if those gains persist throughout medical school and into residency training.

Conclusion 3: HFPS can reinforce basic science knowledge through practical application and recalibrate perceived ability.

Recommendation 3: Medical students must acclimate to the HFPS environment, practice their routines, and adjust their strategies, so HFPS should be methodically and consistently integrated into the medical curriculum.

Simulation should be embedded throughout the curriculum to attain the most benefits from this pedagogy, and this research demonstrated the influence that HFPS has when it is integrated into the medical curriculum, beginning in the first year. Education researchers reporting success with simulation noted that it is weaved into the fabric of their curriculum, beginning early in their students' training, with a thorough orientation to the simulation space, followed by short pre-brief sessions to orient students to the environment prior to participating in simulations (Henneman et al., 2007). McGaghie and

colleagues (2010) argued that the educational and professional context surrounding simulation in medical education is the area of greatest need for further research, claiming, "such contextual features warrant detailed study and understanding so they can be shaped as needed to improve educational results" (p. 60).

It has been observed that after the unfamiliarity of the simulation environment fades, students will have a more mature, sophisticated relationship with the technology and will feel more comfortable and learn more from simulations over time. For instance, after several years of experience conducting simulation with over 400 learners, Dotger et al. (2010) highlighted the importance of providing several opportunities to engage in various simulations since, "the novelty of a participant's first simulation often negates the educational value of whatever context is simulated" (p. 137). Baxter and colleagues (2009) also noted that, "students require access to the equipment and adequate time to use it in order to become more comfortable and less threatened by the technology" (p. 865). In support of this, a medical resident was interviewed for Chapter 7 who had experienced HFPS during their medical education at IUSM-B and explained requiring a few rounds of practice in the IUBIPSC before being able to obtain the full benefits of the debrief.

> [MR-02]:   "I think [the debrief] becomes more important the farther, the more [simulations] that you do because the first, I would say the first one or two times, you're just getting over the fact that you're trying to think, you're trying to tell people what to get ready for next, you're trying to figure out what to do next yourself, but then once you get past that kind of shock and awe, actually maybe the second or third or fourth time that you're going through the simulation where you're really able to know just how they run or what to do, then you can learn more, so I would say the debrief becomes more important after the initial one or two."

Using the realistic environment afforded by HFPS to investigate recalibration of learners' confidence with clinical judgment accuracy is underutilized in education research (Yang, Thompson, & Bland, 2012). Continued practice within the HFPS environment aided medical students in this study to recalibrate their perceived ability towards a more accurate representation of their actual competence. Feedback after HFPS has been described as an essential component of recalibration (Liaw et al., 2012; Moores & Chang, 2009). When incorporated as a regular component of the curriculum, HFPS can support the development of accurate clinical judgment and resolve cognitive disequilibrium through reflection on performance during the simulation (Lasater, 2005).

Additionally, even if some medical students and medical residents interviewed during this dissertation did not see the immediate relevance of HFPS (MS3-01) or found it difficult to transfer training in the HFPS environment to real-world clinical practice (MR-01), HFPS is a staple of modern medical education that will continue to be implemented. Therefore, becoming familiar with this modality early will only benefit medical students moving forward into their clinical careers. The nurse practitioner interviewed for this chapter also commented on observing a solid clinical routine from the IUSM-B medical students because they were able to participate in HFPS training early in their education, perfect their dialogue, then add to their flow over time rather than learning it right before entering clinical rotations.

Conclusion 4: The simulation operator is an important element that imparts fidelity to HFPS scenarios.

Recommendation 4: Initial and continued training of HFPS operators for delivery of

high-quality HFPS experiences is paramount.

The importance of the simulation operator (whose was the 'Simulation

Coordinator' at IUSM-B) was evident as a recurring theme noted throughout this

dissertation research, from the pilot study interviews (see Chapter 4), medical student

surveys and interviews (see Chapters 6), medical resident Q-study analysis (see Chapter

7), and in the interview with the nurse practitioner faculty member (NP) for this

conclusion chapter. The role of the simulation operator at IUSM-B was imperative for not

only providing an authentic experience for medical students, but also offered valuable

formative feedback and assessment as a unique perspective from the supervising clinical

faculty member. The simulation operator at IUSM-B aided in creatively guiding students

through the simulation scenarios acting through the manikin, without explicitly dictating

the procedure or thought process that the students should assume.

> [NP]: "[The IUSM-B medical students] just feel extremely comfortable with the room, they have a format that they use, and they have kind of built off of that, so I see that kind of basic format, that foundation that they all kind of have, each one has taken that and kind of built their own on it. So they can kind of regroup themselves where the other [IUSM medical] students don't have that function, they just get out there and you literally see these blank faces and they're like, 'I don't know where to go from here.' With the Bloomington students…it's like that foundation that's kind of ingrained in there. And then working with [the IUBIPSC Simulation Coordinator] I see where it comes from, because [the IUBIPSC Simulation Coordinator] kind of gives it to them, this is what Dr. so-and-so taught you, this is what Dr. so-and-so taught, and so [the IUBIPSC Simulation Coordinator] kind of reiterates that to them. And so that's where I can kind of see their foundations coming from."

A limitation noted by Henneman et al. (2007) indicated that evaluating achievement in the simulated setting may be difficult if the evaluator is also conducting the simulation (i.e., is the simulation operator) or participating as an actor within the simulation scenario. Therefore, having a dedicated simulation operator frees faculty to focus on student behaviors and decisions. It could also be argued from this dissertation research and the existing literature that much of the fidelity of simulated experiences stems from the operator of the simulation. The need for qualified, highly trained simulation operators is echoed in the Q-study results from Ha (2016), who found that those individuals clustered into Factor III desired proficient, well-experienced administrators and personnel. Ha (2016) recommended training qualified personnel prior to engaging students in HFPS.

McGaghie and colleagues (2010) noted the need for comprehensive, standardized training for simulation operators, stating, "there is a great unmet need for a uniform mechanism to educate, evaluate and certify simulation instructors for the health care professions" (p. 59). The structured training of simulation operators in clinical and technical knowledge will ensure fidelity of the scenarios, and thus should not be left to novices (Gantt, 2012). Skilled simulation operators can also divert a scenario if a student has strayed too far down a path of patient mismanagement (various pathways that simulation scenarios can assume is discussed further in Limitation 2 of this chapter). In these instances of scenario derailment, the attention and responsiveness of the simulation operator is imperative to properly "rescue" the scenario (Dieckmann et al., 2010).

Recent developments in best practices and certification of healthcare simulation operators, accreditation of simulation centers, and continuing education in the form of

various simulation society quarterly journals, websites devoted to simulation, and several conferences dedicated to disseminating simulation efficacy, differentiate quality healthcare simulation education (S. Gindling, personal communication, February 9, 2018).

The largest internationally recognized agency for HFPS is the Society for Simulation in Healthcare (SSH). This professional organization seeks to use simulation to improve patient care through membership, education, certification, and accreditation. SHH awards two different types of certification: Certified Healthcare Simulation Educator (CHSE) and Certified Healthcare Simulation Operations Specialist (CHSOS). At the time of this writing, the IUBIPSC Simulation Coordinator was CHSOS certified. Simulation centers from around the world can apply for consideration of accreditation through SHH's Accreditation Council to obtain recognition as a high-quality simulation program. The IUBIPSC intends to apply for SHH accreditation by May 15, 2019. Through education, certification, and accreditation, SHH advocates for advancing healthcare simulation research and innovation through standards and ethics, and in doing so, enhancing the quality of patient care.

Financial Investment of HFPS Implementation – is it Worth the ROI?

HFPS is a financially steep endeavor (AAMC, 2007) and resource intensive in terms of faculty and staff time (Coombs et al., 2017). The IUBIPSC was constructed in 2012 and the investment was approximately $400,000 in renovations and $550,000 for equipment, supplies, and trained personnel (J. Watkins, personal communication, May 18, 2018). Regarding personnel, one full-time Simulation Coordinator was employed to

manage all simulations within the IUBIPSC. At the time of this writing, this individual is on a 12-month contract through the IU School of Nursing for $72,068.

The high cost of high-fidelity patient manikins (Table 8.1), the investment of finances and space for construction of a room including audio and visual recording systems, and medical supplies and equipment, along with highly qualified simulation operators may be prohibitive to some universities. Additionally, ongoing financial support must be devoted to maintaining software, equipment, replenishing medical supplies, and supporting continuing education for HFPS operators.

Table 8.1: Reported cost of Laerdal Medical Corporation patient manikin simulators effective May 9, 2018

Simulator	Catalog List Price (in US dollars)
SimMan 3G	$74,395
SimMom	$31,460
SimBaby	$29,120
SimNewB	$18,165
SimJunior	$15,195
Resusci Anne	$3,295

How can universities incorporate a HFPS program if financial resources are not available to devote to this educational intervention? The first avenue should be soliciting financial aid through grants and donor support. Several national and private grants are available specifically for use toward HFPS. At the time of this writing, the Advances in Patient Safety through Simulation Research (R18) grant though the National Institutes of Health (NIH) awarded up to $400,000 to develop, test, and evaluate simulation approaches for the purpose of improving the safe delivery of healthcare. The National

Patient Safety Foundation Research Grants Program awards up to $100,000 annually and the Department of Education hosts an annual EdSim Challenge, awarding five finalists $50,000 and one grand prize of $430,000. The Society for Simulation in Healthcare (SSH) lists potential funding sources on their website for HFPS training and the Robert Wood Johnson Foundation offers $100,000 to $300,000 for a wide array of research and initiatives to help address pressing health challenges.

Non-profit and private donations could also be an option for financial assistance. For instance, in 2016 the University of Nebraska Medical Center (UNMC) received a $5.5 million grant from The Leona M. and Harry B. Helmsley Charitable Trust for a mobile HFPS truck to bring life-saving state-of-the-art simulation training to rural emergency responders in low population areas, who might be the only medical providers for miles (Cerino, 2016). Finally, campus and community funding sources could also be available to aid in diffusing the financial challenges associated with HFPS.

It is important to remember that purchasing equipment and manikins will not necessarily guarantee quality educational experiences. HFPS is intended to support learning objectives, and can be destructive to the learning experience if not properly facilitated or utilized (Alinier, 2011). In a systematic review of the literature, Issenberg et al. (2005) noted that the HFPS features that lead to effective learning in medical education were feedback, repetitive practice, and curriculum integration; these factors are not inherent to HFPS. Selecting the most appropriate level of fidelity is dependent on the intended learning goals (Munshi, Lababidi, & Alyousef, 2015), and a minimalist viewpoint (e.g., part-task trainers rather than full-body manikins) may help to avoid cognitive overload (Smallman & St. John, 2005).

While the initial cost of implementing HFPS into a medical curriculum may be high, the present research has demonstrated that the investment for medical students to obtain early exposure to clinical training and teamwork skills in a psychologically immersive environment is well worth the investment for the prospect of patient safety. The potential future savings of producing high-quality functioning physicians upon graduation from medical school, who likely will make fewer costly mistakes, is the goal of medical school. Thus, every effort should be put forth to aid medical students on their path to success, which includes implementation of HFPS throughout the medical curriculum.

Therefore, given the conclusions and evidence-based recommendations for best practices in HFPS just described, can a medical curriculum be proposed that methodically integrates HFPS to enhance and support basic science medical education? The next section of this chapter explores this question and presents a proposed medical curriculum that strategically incorporates HFPS into the first two years of the medical curriculum.

Part II: Proposed Simulation-augmented Integrated Medical Curriculum

The optimal sequencing of simulation content in the medical curriculum, commonly referred to 'integration,' is a continued area of study in the literature (Cendan & Johnson, 2011). For instance, it has been cited that an ideal healthcare curriculum should incorporate a variety of experiential learning situations coupled with meaningful, constructive feedback (Brauer & Ferguson, 2014; Eisenstein et al., 2014). Anderson et al. (2008) argued that the education of future healthcare professionals "must be grounded in germane educational theory and evidence-based strategy" (p. 595). Integrating HFPS into

the curriculum is not only efficacious for the learner, but is also ideal to obtain the most out of HFPS. When HFPS connects clinical and basic science knowledge, medical students increase their confidence, enhance their performance and skills, prepare for their clinical rotations, and align students' attitudes to generally "feel" like physicians (Zafar, 2016).

The use of simulation in preclinical basic science courses is limited (Coombs et al., 2017). Integration of basic and clinical sciences in the first two years of medical school has been shown to increase students' interest while studying anatomy (Roa & Roa, 2009), and effectively develops pattern-based recognition, a form of clinical reasoning, seen in competent practitioners (Carraccio et al., 2008). Torres and colleagues (2014) stated, "the basic course of anatomy in medical education could be recognized as the best example of implementing new educational techniques such as simulation, into the traditional medical curriculum" (p. 2). Therefore, the proposed simulation-augmented curriculum is heavily weighted with examples for Gross Anatomy and Human Embryology.

The promise of patient safety is arguable the most cited benefit for incorporating HFPS in the early years of medical training. Fero and colleagues (2010) concluded that, "given the known risks to patient safety, it is imperative that innovative teaching and evaluation methods be employed to support the development of critical thinking and improve performance outcomes" (p. 2,183). However, it is not enough to construct a realistic HFPS environment and purchase the equipment to fill the room; sound educational strategy is required to obtain the most benefit from HFPS (Seropian, Brown, Gavilanes, & Driggers, 2003).

To craft high-quality simulated experiences for the greatest impact on learning, educators must first identify the learners and the learning needs, then construct HFPS scenarios that provide an ideal balance of challenge and support (Anderson et al., 2008). HFPS is an engaging active learning strategy that aligns with the tenants of adult learning theories (Chipchase, Johnston, & Long, 2012; Coombs et al., 2017). While using HFPS, learners are immersed in a clinically relevant opportunity to apply foundational basic science knowledge. However, recall from Chapter 2, that HFPS is cognitively complex and possesses the risk of overwhelming leaners if its implementation and use is not properly scaffolded (Gorman et al., 2015); therefore, HFPS is likely more advantageous when used as an active learning strategy for reviewing previously learned information rather than learning new material.

As evidence for this aspect of integration from the qualitative interviewing portion of this dissertation research (Chapter 6), one first-year medical student suggested a simulation scenario that better aligned with their coursework.

[MS1-06]: "I think we could have had like an infectious disease one, instead of like the asthma one and trying to figure out what bug someone had and trying to decide what antibiotic and how much to give them I think probably would have made more sense for where we were [in the curriculum]."

Finally, HFPS should also incorporate a self-evaluation and reflection component as advocated by Experiential Learning Theory (ELT). Providing opportunities before, during, and after all major learning experiences for leaners to reflect on their experiences and personal performance is important for establishing accurate self-assessment (Westberg & Jason, 1994). This reflection can be formal assessments (in which learners

complete self-evaluation forms), or informal assessments (where students discuss their experiences with supervising faculty).

As an example from the pilot study of this dissertation research (Chapter 4), one second-year medical student suggested providing a video of their first simulation experience to watch and review, then compare to their current level of knowledge.

[MS2-10]:   "I wish that I could watch a video of the first time I was doing it to the last just to see how nervous I looked or how I was fumbling from thing to thing, versus knowing the steps that you always have to take and the questions that you always have to ask in order to kind of narrow your differential and move forward."

The following proposed simulation-augmented medical curriculum is strategically aligned with learning objectives using backward course design. Thoroughly described by Wiggins and McTighe (2005), backward course design facilitates planned learning experiences and instruction based on identified desired results (i.e., learning goals and learning objectives) that learners should achieve during the course of instruction. This method to curriculum planning is rooted in a learner-centered approach, focusing on the goals of learning in the greater context of the learner's future responsibilities (Davidovitch, 2013). Profound learning occurs when students deliberately practice in relation to their learning goals (Anderson et al., 2008). The proposed simulation-augmented curriculum also revisits topics and concepts in a longitudinal "spiral" curriculum format, uniting integration across time and across disciplines (Brauer & Ferguson, 2014).

Regarding assessment, medical students interviewed during this dissertation research suggested focusing on learning objectives rather than assigning grades for

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HFPS. Having formative feedback rather than summative HFPS events may ease cognitive overload as recommended by Dotger, Dotger, and Maher (2010), in which they explained that learners must be exposed to multiple simulations to allow the novelty of the simulation environment to become normalized. Therefore, in the author's proposed simulation-augmented curriculum, the simulations offered in the fall semester of the first year are non-graded, intended to acclimate medical students to HFPS and provide formative feedback. Thereafter, medical students will be assigned low-stakes grades for HFPS to incentivize preparation and serious performance, without penalizing them for valuable learning through mistakes to mitigate future medical errors.

Role assignment during HFPS (either active roles during the simulation encounter or observational roles of those participating in the simulated scenario) is also an area of current investigation (Weiler & Saleem, 2017). Having medical students rotate through the HFPS event, then observe their peers participating in HFPS, could be an efficient way to expose students to a wider variety of patient presentations and account for a complaint discovered in this dissertation research; during the interviews, a second-year medical student (MS2-13) explained that they had the opportunity to participate in one of several simulation scenarios within each block of material before exiting the IUBIPSC without observing their peers, thus missing pertinent information from other HFPS pathologies within the block of material.

Rotating roles in HFPS could also provide a practical way for larger medical schools (e.g., hundreds of medical students compared to the IUSM-B class of 36) to utilize HFPS in their curriculum. For those learners not actively participating in the simulated scenario, their observations and critique of peers may still result in educational

benefits (Cordovani and Cordavani, 2016; Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009; Jamniczky et al., 2017). However, active observer roles during multiple-participant simulations lead to higher ratings of self-efficacy (Weiler & Saleem, 2017); therefore, active roles are assigned to all medical student peers that observe the simulation in the author's proposed simulation-augmented curriculum; the active observers provide both written and oral feedback (in addition to the supervising instructor) to the medical student participating in the HFPS scenario.

Finally, it is valuable to remember, not only from the literature review but also from the results of this dissertation research, that HFPS in this proposed curriculum is utilized as an important supplement to enhance existing medical training (Coombs et al., 2017). When used as an adjunct, HFPS supports the encoding of basic science information through practical, experiential applications. However, HFPS cannot replace the plethora of other experiences required to produce a well-rounded, competent physician.

Figure 8.1 presents a hypothetical two-year medical curriculum and Table 8.2 strategically outlines various simulation adjuncts to supplement traditional (e.g., lecturing) and non-traditional instruction (e.g., case-based learning (CBL), team-based learning (TBL), problem-based learning (PBL), etc.). The medical course and lecture topic are listed in the first two columns of the table, while the goals of the activity and specific simulation equipment required for each topic are articulated under the columns titled 'Learning Objectives' and 'Simulator,' respectively. While the author acknowledges that institutional financial pressures and demands on faculty and staff time may limit the feasibility of this hypothesized curriculum, the author has reviewed and

combined the comments, suggestions, and literature into this hypothesized curriculum for the efficient and effective integration of HFPS in the IUSM medical curriculum. The presented simulation-augmented curriculum is a conglomeration of concepts developed by the author in addition to those presented by the following articles: Coombs et al., 2017; Cendan & Johnson, 2011; Harris et al., 2014; Rosen, McBride, & Drake, 2009; Sperl-Hillen et al., 2013.

Figure 8.1: Hypothetical medical curriculum of the first two years

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Year 1: Foundations of Basic Clinical Science	Gross anatomy & Histology					BREAK	Neuroscience			
	Biochemistry						Physiology			Intro to Pathology
			Human embryology & Genetics				Microbiology		Immunology	
	Interprofessional Education (IPE) / Foundations of Clinical Practice (FCP)						Healthcare Team Leadership			
Year 2: Foundations of Pathological Science	Cardiovascular & Hematology					BREAK	Neurology & Psychiatry			
		Renal & Respiratory					Endocrine & Reproductive Biology			
			Gastrointestinal & Nutrition					Musculoskeletal & Dermatologic		
	Interprofessional Education (IPE)						Advanced Clinical Skills (ACS)			
	Preceptor Rotations						Preceptor Rotations			

This hypothetical curriculum is adapted by the author based on the following medical school curricula: IUSM, Phase One Curriculum; The University of Texas at Austin Dell Medical School, Leading EDGE Four-Year Curriculum; Duke University School of Medicine, Foundation for Excellence Curriculum; and Harvard Medical School, Pathways Curriculum Map.

Table 8.2: Outline of learning objectives and simulators required for selected courses from the hypothesized medical curriculum (Figure 8.1)

Course	Lecture Topic	Learning Objectives	Simulator
Year 1: Foundations of Basic Clinical Science			
Biochemistry	Sickle cell anemia	• Obtain the patient's medical history • Summarize the signs and symptoms of sickle cell anemia • Compare and contrast sickle cell anemia with beta thalassemia • Devise a treatment plan for sickle cell anemia • Educate the patient in lay terms regarding their condition	SimMan 3G
Biochemistry	Obesity, hypertension, and diabetes	• Measure plasma levels of total cholesterol, triglycerides, and individual lipoproteins for dyslipidemia • Diagnose and begin insulin treatment • Manage insulin resistance and provide patient education	SimMan 3G + obese moulage
Gross anatomy & Human embryology	Gross anatomy of vertebral column and spinal cord	• Describe the relevant vertebral and spinal anatomy for performing a lumbar puncture • Palpate the surface anatomy for lumbar puncture location • Demonstrate proper lumbar puncture technique	Lumbar puncture part-task trainer
Gross anatomy & Human embryology	Gross anatomy of breast, pectoral region, and axilla	• Identify the bony landmarks of the pectoral region and four quadrants of the breast • Trace the lymphatic drainage from each breast quadrant to their appropriate lymph nodes • List the specific nerves and vasculature to be cognizant of while performing a mastectomy	Breast examination part-task trainer

	Gross anatomy of thoracic wall, pleural cavities and lungs	• Demonstrate pulmonary auscultation sites • Locate the thoracic bony landmarks used in CPR and perform CPR in adults, children, and infants • List presentation signs and symptoms associated with tension pneumothorax • Identify surface landmarks and location within intercostal space for needle decompression and chest tube insertion • Explain the anatomical reason for developing tension pneumothorax	Resusci Anne Harvey Cardio-pulmonary Patient Simulator SimMan 3G + trauma moulage kit SimBaby
	Gross anatomy of heart	• List cardiac auscultation areas • Recognize normal heart sounds • Demonstrate locations for peripheral pulses • Accurately measure blood pressure using a sphygmomanometer	Harvey Cardio-pulmonary Patient Simulator
	Embryology of heart	• Recognize heart sounds for atrial septal defects (ASD) and ventricular septal defects (VSD) • List the anomalies associated with Tetralogy of Fallot • Recognize the presentation of and diagnose patent ductus arteriosus (PDA)	SimBaby
	Abdominal viscera – gallbladder and vermiform appendix	• Explain the anatomical basis for developing choleliths and appendicitis • Recognize the segmental regions of referred pain associated with each condition	SimMan 3G
	Gross anatomy of larynx, pharynx and soft palate	• List indications for performing endotracheal intubation • Demonstrate the correct anatomical location for a laryngoscope blade and endotracheal tube placement	Endotracheal intubation part-task trainer

	Embryology of head and neck – meninges, dural folds and dural venous sinuses, cerebrospinal fluid	• Recognize fontanel appearance for elevated intracranial pressure • Compare and contrast the anatomical features of epidural versus subdural hematoma • Identify various presentations of pupillary dysfunction as signs of intracranial injury	SimBaby (displaying simulated bulging anterior fontanel)
	Pregnancy and parturition	• Recognize the signs and symptoms of adherent placenta and postpartum hemorrhage • Administer pitocin & demonstrate transabdominal massage of the uterus • Know when to, and accurately perform, a manual removal of placenta (MROP) procedure	SimMom and SimNewB
Physiology	Cardiovascular system – hemorrhagic shock	• List the presenting signs of a patient with hemorrhagic shock (e.g., tachypnea, normalized O2 saturation, tachycardia, hypotension) • Palpate weak pulses on a hypotensive patient • Discuss the physiologic concepts of preload, venous return, stroke volume, and cardiac output in a patient experiencing hemorrhagic shock • Describe the treatment that should be initiated for hemorrhagic shock (e.g., saline bolus)	SimMan 3G
	Pulmonary system – asthma	• List the presenting signs of a patient with an acute asthma attack (e.g., tachypnea, decreased O2 saturation, tachycardia, hypotension) • Explain the clinical relevance of the oxyhemoglobin dissociation curve • Predict pulmonary function tests on a patient with acute asthma	SimJunior

Neuroscience	Stroke	• Observe and report the patient's orientation, activity, timing of symptoms, headache location, and past medical history • Conduct a thorough physical examination including pupil-eye movement, cranial nerve check, heart/lung/abdominal examination, balance check, sensation check, and pulses • Order appropriate diagnostic tests (e.g., head CT (non-contrast), finger stick coagulation test) • Interpret diagnostic test results and generate an appropriate treatment plan	SimMan 3G
	Psychotherapy and Personality Disorders	• Diagnose and discuss treatments of various psychotherapy and personality disorders (e.g., depression, bipolar and anxiety disorders; Autism spectrum disorder, antipsychotics) • Practice breaking difficult news to parents and loved ones	SimJunior Standardized Patient
Immunology	Infection Detection	• Obtain the patient's medical history of the present illness • Perform a physical examination • Create a differential diagnosis list of suspected bacterial and/or microbial pathogens • Decide the appropriate medication (e.g., antibiotic, antifungal) • Confirm with the pharmacy regarding the appropriate dosage of medication based on your patient's physical examination	SimMan 3G

Year 2: Foundations of Pathological Science		
Cardiovascular & Hematology	• Revisit cardiovascular disorders and expand on prior knowledge (e.g., hypertension, angina pectoris, myocardial infarction, mitral/aortic valve stenosis and regurgitation, cardiomyopathy) • Perform phlebotomy following recommended best practices	Harvey Cardio-pulmonary Patient Simulator Phlebotomy part-task trainer

Renal & Respiratory	• Explain conditions that require urethral catheterization • Demonstrate physical examination and the procedure for urethral catheterization in both males and females • Recognize the signs and symptoms of various respiratory pathologies (e.g., respiratory distress syndrome, pneumonia, pulmonary hypertension, COPD, asthma, atelectasis)	Catheterization part-task trainer (male and female) SimMan 3G SimNewB
Gastrointestinal & Nutrition	• Diagnose and formulate a treat plan for various gastrointestinal presentations (e.g., gastric ulcer, cholecystitis, diverticulosis/ diverticulitis, Crohn's disease, pancreatitis) • Educate patients on proper dietary plans from evidence-based recommendations	SimMan 3G Standardized Patient
Musculoskeletal & Dermatologic	• Compare and contrast infectious and non-infectious skin lesions • Identify common types of skin lesion presentations • List causes, associated symptoms, and current evidence-based treatments for common types of skin lesions	SimJunior + dermatology moulage kit
Endocrine & Reproductive Biology	• Evaluate and diagnose various endocrine pathologies (e.g., hypocortisolism, hyperthyroidism, diabetes)	SimMom and SimNewB
Neurology & Psychiatry	• Differentiate between ischemic and hemorrhagic strokes • Diagnose and explain management of multiple sclerosis	SimMan 3G

* This presented curriculum is an amalgamation of concepts developed by the author and presented by the following articles: Cendan & Johnson, 2011; Coombs et al., 2017; Harris et al., 2014; Rosen et al., 2009; Sperl-Hillen et al., 2013

Part III: Study Limitations

Due to confounding variables and complex synergistic interactions, determining

the effectiveness of educational interventions is very challenging (Hutchinson, 1999;

Wilkes & Bligh, 1999), and evaluating the direct impact of training interventions on patient care is even more difficult (Kuduvalli, Parker, Leuwer, & Guha, 2009). The case study design of this research also induced various restrictions on the generalizability of this research. Although several strategies were employed to combat the inherent limitations associated with this research, the effect from the limitations permeated the results and will be reviewed next. The limitations are organized into 10 areas, and include: using the OSCE as a proxy variable; challenges associated with HFPS research; case study design and external validity; questionnaire distribution; homogenous population, sample size, and self-selection bias; incentive for study participation; threats to questionnaire validity and quantification of subjectivity; medical student and medical resident survey fatigue; faculty-developed simulation rubrics; and qualitative methodology limitations. Part V describes future directions that could address many of these limitations.

Limitation 1: Using the IUSM OSCE as a proxy variable

Arguably, one of the greatest limitations of this research was discovered during the qualitative interviewing (see Chapter 6), in which IUSM medical students revealed their experiences and opinions regarding the OSCE. Although the OSCE is based on performance of clinical tasks and skills, similar to those seen while participating in HFPS (e.g., obtaining patient medical history, auscultation, etc.), the IUSM OSCE was found to not replicate reality as HFPS does. The IUSM OSCE was described by the medical students as assessing specific, isolated tasks (e.g., listen to each abdominal quadrant for a given amount of time, make sure the bed was elevated to a specified height while

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performing some physical examination maneuvers, etc.), while HFPS focused on more global aspects of whole patient care (e.g., gather all pertinent patient medical history and reason for the current visit, order appropriate diagnostic tests and medical images, generate an inclusive list of differential diagnoses, and formulate a treatment plan).

Additionally, IUSM medical students interviewed claimed that rubrics for successfully completing the OSCE were not provided to them; this aspect is in contrast to HFPS, in which IUSM-B students not only received information prior to the simulation, but were also given immediate feedback during the debrief following the simulated event. The OSCE was an inadequate measure for HFPS performance, and thus questions may arise as to why the OSCE was selected as a proxy variable for competent behavior.

The OSCE appeared to be a reasonable proxy measure for competence based on the performance aspect of this assessment, and OSCEs have been utilized as a proxy measure for competent behavior in existing educational research studies (Brand & Schoonheim-Klein, 2009; Byrne & Smyth, 2008; Hsu et al., 2015; Jolly et al., 1996; Mårtenseson & Löfmark, 2013; Mavis, 2001; McClimens et al., 2012; Nolan et al., 2017; Weiner et al., 2014). However, the IUSM OSCE was found to be an inadequate HFPS proxy variable because the OSCE focused on, and assessed, isolated clinical tasks (see Chapter 6), whereas HFPS tended to assess more integrated skills in a complete patient encounter (Liaw et al., 2012).

Medical students must take and pass a plethora of examinations as they progress through their training. When utilizing high-stakes, required examinations for medical education research, insurmountable confounding variables are associated with identifying causality. Although the OSCE is not a nationally required examination, IUSM medical

students must pass the IUSM OSCE each year to progress through the degree. Given the requirement to successfully pass an IUSM-prepared OSCE, medical students may have employed additional extracurricular compensation study strategies if they believed that the instruction through their program was inadequate (Jolly et al., 1996), and Chen, Lui, and Martinelli (2017) explained that high expectations and social pressure associated with required examinations confound medical education scholarship and bias research results. Such strategies to make up for deficiencies in their training for the IUSM OSCE could have included soliciting advice from more senior level medical students regarding their IUSM OSCE experiences or conducting online searches for posted OSCE rubrics from other programs, which would confound the results of this study.

As described further in the Future Directions section in the next part of the chapter, a better proxy measure for simulation performance may reside in physician-faculty and preceptor ratings of student performance of actual competence rather than a standardized examination. Using preceptor assessment of clinical skills has been utilized in previous studies (Beckham, 2013; Colletti, 2000; Huang & Grigoryan, 2017), and may better allude to the efficacy of transferability of HFPS performance to real-world practice. However, these ratings of student performance would have to be standardized and interrater reliability determined among preceptors would need to be done before one could state that these evaluations of student performance are adequate proxies.

Limitation 2: Challenges associated with HFPS research

Quantifying the educational efficacy of HFPS presented several challenges in addition to the plethora that is inherent to education research in general. Investigating

HFPS is immensely difficult due to a number of factors, including the fact that simulations are typically integrated into the curriculum, which makes it difficult to discern learning outcomes specifically attributed from simulation compared to other curricular activities (Weller et al., 2012).

Integrating HFPS into the curriculum makes it difficult to quantify direct benefits of simulation, as exemplified in the observations made by Coombs and colleagues (2017), in which they acknowledged that although they observed statistically significant higher posttest scores after simulator use (which included high-fidelity manikins, part-task trainers, models, and Standardized Patients) compared to pretest scores, they were unable to definitively conclude that acquired anatomy knowledge of 81 first-year medical students was exclusively obtained from participating in simulations. Since some of the material taught during the simulation sessions was also covered in concurrent components of the curriculum (such as didactic lectures, case-based learning sessions, and gross anatomy laboratories with plastinated specimens, radiologic images, and virtual dissections) the authors noted a limitation encountered by all simulation researchers — the difficulty in measuring the exact influence that simulation has on learning and practice.

It is difficult to parse out one specific educational intervention from the pool of resources and experiences that learners are exposed to within their curriculum. Due to confounding variables, discovering the direct and specific influence of HFPS on various aspects of learning, such as on students' self-efficacy, is difficult. Therefore, many HFPS investigations focus on simple correlations (Weiler & Saleem, 2017) or perception data (Landeen et al., 2015; Reising et al., 2011). Although this lack of rigor and objectivity in

HFPS literature is apparent (Issenberg et al., 2005; Liaw et al., 2012), focusing on specific, isolated psychomotor tasks and skills related to HFPS, such as thoracocentesis (Barsuk et al., 2017; Jiang et al., 2011) and laparoscopic surgery (Fried et al., 2004; Lucas et al., 2008), would ultimately represent a small portion of the overall simulation experience and simplify the inherent complexity associated with this instructional intervention.

Cognizant of these challenges, this study aimed to understand the general impact of HFPS on different medical student populations. The author attempted to account for this limitation by constructing a multi-faceted study design that incorporated both quantitative and qualitative approaches to answer the research questions. This strategy intended to ensure a more complete evaluation of a very complex learning environment (Chen et al., 2016). However, although measures were developed to account for the complexity of HFPS learning in the broader context of clinical exposure and curricular experience, the author acknowledges that it is impossible to discern the direct influence of HFPS on medical students within this study that may manifest years later.

Performance anxiety associated with HFPS likely permeated many aspects of this research as well. In a study of nursing students using high-fidelity simulations, Fero and colleagues (2010) noted that students who performed alone may have experienced elevated anxiety levels thus influencing their performance. Since HFPS was integrated into the first-year, second-year, and third-year medical curricula at IUSM-B, students are repeatedly exposed to the IUBIPSC and are thus given time to overcome much of the anxiety when participating in HFPS that has been described in the literature (Dotger et al., 2010; Landeen et al., 2015).

Evaluating simulation effectiveness is also challenging given that a simulated exercise may deviate from a particular path, depending on the responses from the learner or those from the manikin or SPs. For example, when developing flexible scenarios for HFPS, O'Regan and Coombs-Thorne (2017) recommend creating at least three to four pathways: 1. An anticipated pathway; 2. A no-management pathway; 3. One or two mismanagement pathways. Creating and anticipating for these various pathways will allow for proactive implementation of the scenario to unfold based on the learner's actions and the physiology presented by the manikin. To mitigate the effect of these varying pathways when evaluating students during simulation, Henneman and colleagues (2007) suggested preparing rubrics based on expected student outcomes of specific, observable behaviors. Following this suggestion, IUSM faculty-developed rubrics of HFPS experienced by second-year medical students in the IUBIPSC were consulted in this study for Research Question 2.

Ha (2016) noted one limitation in their study revolved around students having different instructors for their simulation experience, which may have influenced attitudes. This limitation was largely avoided with the case study nature of this project as a single individual, the Simulation Coordinator, conducted all simulations at the IUBIPSC at the time of this study. However, although this single-site study does reliably produce simulated experiences for students, threats to external validity are apparent.

Limitation 3: Case study design and external validity

Although this research provided a surfeit of data regarding the IUBIPSC, it is limited by focusing on a single simulation center with single cohorts of medical students

and medical residents. Therefore, this study's results and conclusions limit the external validity, or generalizability, which is the ability for results to extend beyond the current research situation (Flick, 2009). Therefore, the case study design of this project yielded information with great depth, but limited breadth. Two strategies were utilized to enhance the possibility of transference, including 'rich description' and 'maximum variation.' These two strategies will now be described in more detail.

Merriam (2009) explained that rich description is, "a highly descriptive, detailed presentation of the setting and in particular, the findings of a study" (p. 227). Meticulously described data will allow readers to contextualize the study and determine the extent of transferability. The detailed explanation of the high-fidelity manikins and equipment used in the IUBIPSC parallel that found in a typical high-fidelity simulation center, and the exact sequence that medical students are exposed to during HFPS within the IUBIPSC was outlined, which is common in most HFPS experiences (e.g., begin with a pre-brief orientation, which is followed by the simulation, and ending with a debrief). Therefore, results from this research may be applicable in different locations with similar simulation contexts.

The second strategy to enhance external validity, maximum variation, is the attention to sample selection in order to increase the variation for greater range of application (Merriam, 2009). All students from IUSM-B classes of 2018 through 2020 and medical graduates from the classes of 2015 through 2017 were invited to participate in the research. The data obtained from the pool of 276 potential participates (including both medical students and medical residents) helped to broaden the range of responses

and experiences for a more comprehensive view of HFPS incorporated within the medical curriculum.

Limitation 4: Questionnaire distribution

Although the questionnaire was intended to be distributed as close as possible prior to students taking their performance-based assessments (approximately one week prior to the OSCEs), logistical considerations among three campuses as well as the need for follow-up invitations forced the survey to be distributed approximately two weeks prior to the exams. This timing was similar to the method employed by Jolly and colleagues (1996), who also distributed their clinical experience questionnaire two weeks prior to the OSCE.

However, this timing may have influenced the results in this dissertation research. Many interviewees indicated feeling unprepared for the OSCE until they massed practiced just days prior to the exam. This significant increase in preparation immediately prior to the OSCE may have altered their original ratings of their self-efficacy and preparedness as indicated on the questionnaire (see Chapter 5). Both medical students from the intervention group and from the control group expressed this sentiment.

> [MS1-07]: "When I had taken the survey I just hadn't practiced enough, but before the OSCE I practiced more, so I did, I did well. I felt prepared by then…so like my answers [the self-efficacy ratings] I think would change a little bit, go up. I think a lot of us like, put off learning how to do some of that stuff until like that week of the OSCE, so, maybe the timing of when people took it might change their answers."
>
> [MS1-02C]: "I felt better about it when I practiced a little bit more coming up closer to the date."

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Acknowledging that distributed practice is superior to massed practice, a study was conducted on 20 PGY1 through PGY3 residents to determine the most effective distributed practice schedule for learning bronchoscopy skills through simulation (Bjerrum, Eika, Charles, & Hilberg, 2016). The residents were randomly assigned to either a one-day distributed practice schedule or a weekly-distributed practice schedule. Through analysis of immediate pretests and posttests and a 4-week retention test, the researchers found no significant difference in the effectiveness of bronchoscopy skill acquisition between the two distributed practice schedules. The authors concluded that one-day of distributed practice may be effective to acquire bronchoscopy skills.

Another study investigated massed practice to distributed practice for learning skills on a laparoscopic surgical trainer among 41 medical undergraduates and postgraduates (Mackay, Morgan, Datta, Chang, & Darzi, 2002). The participants were randomly assigned to one of three groups: 20 minutes of massed practice (Group A), 20 minutes of distributed practice in 5-minute block increments (Group B), or 15 minutes of distributed practice in 5-minute block increments (Group C). Analysis of retention tests revealed a statistically significant difference between Group A and Group B (with Group B outperforming Group A), but a non-statistically significant difference between Group A and Group C. These findings support the notion that distributed practice is more beneficial than massed practice for learning laparoscopic surgical skills using simulation.

Although unrelated to medical education, an investigation of learning decomposition between massed practice compared to distributed practice of 346 children in the Pittsburgh area analyzed reading proficiency (i.e., reading words quickly and accurately using a computer-based reading program). The authors discovered that massed

practice was generally not effective; however, massed practice was an effective strategy for a subset of five students (Beck & Mostow, 2008). These five students were characterized as less proficient than their peers and were identified as requiring learning support.

Additionally, some interviewees in this dissertation research indicated that stress from other high-stakes examinations occurring around the same time as the OSCE may have influenced their questionnaire responses.

[MS2-13]:   "I was in quite a negative aspect when I took this survey because this was right before Step 1."

Finally, in accordance with IRB protocol, the researcher was dependent on administrative assistants and course directors who were knowledgeable of the participant emails to distribute the study invitations to their medical students. An initial email and a follow-up email approximately one week later were sent to each IU campus representative. The researcher is unable to verify if the representatives forwarded the study invitation emails to the medical students at their campus. The total IUSM-E first-year medical class of 2020 was 24 students, and after recruitment, zero first-year medical students from that campus were included in this research lending support to this inherent limitation.

Limitation 5: Homogenous population, sample size, and self-selection bias

Several limitations related to the population sampled from, the size of the sample obtained after recruitment, and the voluntary nature of this study. Each of these limitations will be briefly described next.

Homogenous population

Conclusions drawn from this study may not be able to be generalized to a larger, more diverse population. The medical students who attended IUSM at the time of this study were relatively homogenized demographically regarding their ages, academic performance, and general backgrounds (V. O'Loughlin, personal communication, February 9, 2018). This is inherent and unavoidable limitation in educational research that implements a case study design. As described in the next section detailing future directions, a multi-institutional study could account for this particular limitation.

Sample size

The fairly small medical classes of the three IUSM campuses in this study created another challenge regarding the sample size obtained for this study. IUSM-B had 36 first-year medical students, 36 second-year medical students, and eight third-year medical students; the IUSM-E campus had 24 first-year medical students and 23 second-year medical students; and IUSM-FW had 32 first-year medical students, 29 second-year medical students, and 12 third-year medical students.

Field (2013) presented a discussion regarding the minimum sample size required for adequate statistical power and concluded that a widely accepted value of 30 participants, and in distributions with few outliers, a sample size of 20 may be large enough. Skewness and kurtosis may necessitate a large sample size of up to 100 or more (Field, 2013). Therefore, given the small class sizes of the population sampled from, statistical significance could not be achieved. According to G*power (Version 3.1.9.1), an open-source statistical power analysis program, an ideal sample size to discover a

moderate statistically significant effect for this research would have been the following: 210 individuals for the *t*-tests (105 individuals in each group); 138 total individuals for the Pearson correlations; and 210 total individuals for the ANCOVA.

As discussed in potential future directions, a multi-institutional study design, rather than the case study design utilized in this research, could combat this sample size issue.

Recruitment and self-selection bias

It is difficult to interpret and generalize findings from this study due to the voluntary bias that may have permeated the results. In a 2015 study, Landeen and colleagues commented on the limitation surrounding the necessary voluntary nature of their perception study and the possibility that only those nursing students with strong opinions about high-fidelity simulation may have participated. They commented that recruitment was an issue and response rates were disappointing even with the incentive of being entered into a drawing for an Apple® iPad. Hunziker and colleagues (2010) noted that a potential limitation in their study of medical students during CPR simulations was the voluntary nature of the study, which may have selected for more motivated participants. This particular limitation was unable to be avoided, as voluntary participation was a required component for the IRB approval of this research.

Limitation 6: Incentive for study participation

To obtain a wider field of respondents for this study, all participants were informed of their entry into a random drawing for a $100 Amazon.com Gift Card upon

completion of the questionnaire or Q-sort. However, according to a recent report by Royal and Flammer (2017), health professions students are more likely to complete surveys when guaranteed a small incentive (such as small cash prizes or a gift card of $5, university apparel, or coupons for coffee) as opposed to a large lottery drawing for cash (e.g., $250) or products (e.g., electronic tablets). This finding is due to the fact that potential survey participants weigh their odds of winning a single prize of considerable value, then compare these odds to the time and effort required to complete a survey, "confirming why response rates typically experience only a trivial increase when lottery-based incentives are used" (Royal & Flammer, 2017, p. 344). The authors' study did indicate that for a large prize, the composite likely to participate was 77.2%, which was still substantial; however, they concluded by suggesting that researchers should offer multiple small incentives to guarantee receiving something, or at least increase the odds of winning, to optimize data collection.

Limitation 7: Threats to questionnaire validity and quantification of subjectivity

The self-efficacy questionnaire utilized in this research underwent rigorous development and incorporated recommended design elements (see Chapter 3 and Chapter 6), including following the Delphi technique for accurate inclusion of questionnaire items, validation through a pilot test with a small group of medical students, and general peer-review. However, interview data relied heavily on the quality of participant responses and interviews revealed inconsistencies in item interpretation, consensus of question interpretation, and confusion with both the self-efficacy rating scale and the Dreyfus rating scale items.

For example, one item on the questionnaire asked respondents to rate their overall

ability as a clinician at this time in their medical career. The scale provided was based on

the revised version of the Dreyfus Model of Skill Acquisition, which included the

following six labels: Novice, Advanced beginner, Competent, Proficient, Expert, and

Master. For ease of item discrimination and interpretation, definitions and examples were

provided for each ranking, as outlined by Park (2015). Threats to validity on this

particular item were noted during the interviews, including, context relevance and

inability to scrutinize the question stem. Context relevance was discovered as some

interviewees commented that the presented descriptions of the Dreyfus scale were

irrelevant or confusing to discriminate between while completing the questionnaire.

[MS1-07]: "I think it's kind of hard, when you see what's written here. I still need to follow specific rules and stuff and like, we're thrown so much information sometimes it's hard to know what is important and what is not. But I wouldn't say I need maximum guidance because I think we had to do a lot of outside work on our own or in groups so I'm not usually seeking guidance that way."

Additionally, some medical students were unable to scrutinize the question stem.

It is unknown after the interviews if this uncertainty was due to confusion regarding the

item presented or if it was due to rapidly finishing the questionnaire without fully

considering the question prior to answering. Analysis of the duration required by

respondents to complete the questionnaire also alluded to obtaining superficial results.

The average length of time to complete the questionnaire was 4.4 minutes for the

intervention group and 6.8 minutes for the control group. Therefore, even after the pilot

study, the results of this research may be confounded by hastily completing the

questionnaire, not answering (i.e., "skipping") some of the questions, or through

misunderstanding the meaning behind the question.

Social desirability may have permeated results for both the self-efficacy ratings

and the Dreyfus ratings as well. Social desirability can occur when interviewees desire to

make a good impression on the interviewer or falsely deny engaging in socially

undesirable behaviors; this concept is defined as, "the tendency to provide answers that

put one in a good light with the person who asks the question" (Dillman et al., 2014).

This concept is slightly different from the "Unskilled and Unaware Effect" (also referred

to as the Dunning-Kruger effect) presented in Chapter 5, because in this instance, the

respondent is aware of their limitations, however, they simply desired to be at a higher

skill set than they had currently attained. For example, one first-year medical student

from the control group selected what they thought that they wanted rather than what they

actually believed while answering the Dreyfus rating question.

> [MS1-01C]:   "Maybe just like my personality I guess infused in that
> decision, but I think if you were to, I think it's inflated
> obviously, I think I'm not proficient at all."

Although the self-efficacy variable was a subjective indicator elicited from the

respondents own beliefs, bias was minimized by using explicitly defined categories,

which was a similar procedure done by Grantcharov and colleagues (2004). Bias was also

minimized by utilizing a 0 to 100-scale format, which is a psychometrically stronger

response scale than the traditional 1 to 5-scale Likert format (Pajares et al., 2001).

Limitation 8: Medical student and medical resident survey fatigue

Medical students are constantly bombarded with various surveys and questionnaires in almost every class and clinical encounter at IUSM. Survey fatigue is defined as the time and effort required to participate in a survey with overexposure to the survey process leading to diminished response rates (Porter et al., 2004). Repeated study of the same population of learners by multiple investigators may lead to a variety of errors in measurement including 'item nonresponse,' where respondents skip questions or fail to complete the entire survey (Dillman et al., 2014). Survey fatigue may also lead to a phenomenon known as 'straight lining,' in which respondents give the same answer to every item in a grid of questions (Kim et al., 2018).

In an attempt to avoid confounding factors associated with survey data collection, specific guidelines for survey design as recommended by Dillman et al. (2014) were utilized. Based on these recommendations, the "Medical Student Self-Efficacy and Simulation Perception Questionnaire" (Appendix A and Appendix B) was developed as a succinct data collection instrument to maximize the response rate, with specific questions targeted to answer the research questions. The length of the questionnaire was considered given that Jolly et al. (1996) found that lengthy questionnaires inhibited their response rate by 15%. As explained in Chapter 3, questionnaire items were validated by physician-faculty and simulation experts via the Delphi technique, followed by a pilot study to refine item wording and verification of acceptable length and time to complete the questionnaire.

Limitation 9: Faculty-developed simulation rubrics

Simulation scores were utilized from the second-year medical students within the intervention group (IUSM-B) to answer Research Question 2. As explained in Chapter 3, the simulation performance scores were obtained from rubrics developed by IUSM-B physician-faculty, and thus the rubrics reflected what the faculty valued in assessment of simulation performance. Additionally, the simulation performance rubrics had not been assessed for reliability or validity by faculty prior to utilization in this dissertation research, and the faculty admitted to the author about the subjective nature of the rubrics and their assessment of the medical students while observing simulations. HFPS was described as a relatively new intervention introduced into the medical curriculum by the physician-faculty; thus the faculty admitted that bias error (i.e., grade leniency, or biased grade inflation) likely permeated the scores, with higher scores given to the medical students than they probably should have received.

Limitation 10: Qualitative methodology limitations

The directed approach to qualitative content analysis (QCA) was utilized in the interpretation of medical student transcripts, while Q-methodology was employed to analyze medical resident viewpoints regarding HFPS. Limitations are associated with each of these methodologies.

A hallmark of qualitative content analysis (QCA) is the ability to perform inter-coder reliability for unbiased interpretation (Pfeil & Zaphiris, 2009). Due to time and logistical constraints imposed in this dissertation research, agreement in qualitative coding was unable to be determined. Future directions should incorporate a Kappa

statistic (to measure interrater reliability) as well as the confidence interval between raters

regarding consensus in the coding procedure (Jamniczky et al., 2017).

However, as part of the qualitative validation process, all 21 medical student

interviewees were sent a 'member checking' email (Merriam, 2009). Recall that member

checking is a method employed in qualitative research to establish trustworthiness in the

results and conclusions. The member checking email was sent to all interviewed medical

students in this study and contained a short message reminding the student of the purpose

of the study and included three attachments: the specific recorded interview with the

student, the typed transcript, and a brief synopsis of the author's evaluation of the

interviewee's opinions from the qualitative interpretation found in Chapter 6. Each

interviewee was told that all data had been redacted so that their quotes and opinions

were completely anonymous in the dissertation manuscript. The member checking email

also informed each medical student interviewee that if they believed the author had

inaccurately analyzed their position on anything, or if they had any other comments

regarding their clinical simulation experience, they should not hesitate to contact the

author. Recall from Chapter 6, seven confirmation emails from interviewees were

received; all respondents agreed that the materials and interpretation of their position was

accurate.

Although statistical at its roots to discover qualitative viewpoints, Q-methodology

is not without its inherent limitations. The systemically guided interpretation based on the

structure of the factor arrays, in addition to citing the item numbers and rankings within

the factor narrative, does lend considerable support for an unbiased approach to

qualitative interpretation; however, as Watts and Stenner (2012) noted, "an interpretation

is always and forever an interpretation" (p. 163). Different Q-methodologists or participants themselves may view the factor interpretation differently and subtle elements may be overlooked if a thorough and methodical analysis is not employed.

The author has attempted to avoid these biases by following recommendations in Q-methodology literature (see Chapter 3), thoroughly described the course of data collection and analysis (see Chapter 6), and consulted with a Q-methodologist on the interpretation of the Q-study for this dissertation research. However, all qualitative research is not without an interpretation limitation (Watts and Stenner, 2012).

Ha (2016) also stated that the Q-sort process, in which participants sort pre-determined statements first into piles of agree, neutral, and disagree, and then a second round sorts those three piles into a quasi-normal grid for more precise rankings (see Figure 3.6), requires a brief orientation prior to sorting, sorting is time-consuming, and requires quiet spaces with large tables for manual sorting. Given this involved Q-sort process, recruiting busy medical residents who had experienced simulations in the IUBIPSC for this study was challenging. To counteract the time-consuming nature of manual sorting, a digital sorting method was employed that included a user-friendly interface and clear instructions (see Chapter 5). However, Dillman et al. (2014) suggested providing respondents with multiple ways to participate in a study to reduce nonresponse error because, "offering people the mode they prefer increases the speed by which they respond and has been shown to increase response rates" (p. 402). Medical residents interested in participating in this study were given the opportunity to complete the Q-sort electronically or to be mailed a physical Q-sort with a self-addressed, stamped return envelope (no medical residents requested this manual sort option).

Part IV: Future Directions

The results from this dissertation research demonstrate the potential utility of HFPS as an integrated component of the medical curriculum. Additional research is needed in order to comprehensively confirm the findings presented here and to extend existing knowledge for future patient safety. Several limitations were noted in the previous section and improved methodologies to investigate the research questions were conceived as data collection commenced. The following directions outlined below can be implemented for future iterations of this research and take the limitations into account. These future directions could potentially add meaningful data to the pool of existing evidence for the implementation of HFPS in medical education.

Some participants in this study had a difficult time suspending their disbelief, which was found in both the medical students (see Chapter 6) and the medical residents (see Chapter 7). Identification and support of various learner mentalities and personality types may enable targeted simulations to specific interests and preferences. As previously noted, continued enhancement of fidelity through advanced technology such as robotics, may support those learners confronted with a difficult time believing the manikin was a real patient (Luctkar-Flude et al., 2012). Virtual reality (VR) is increasingly becoming accessible as a viable educational intervention and may also aid students in suspending their disbelief, as the static face of a plastic manikin can be virtually replaced by an animated image of a loved one or someone that they know.

As previously outlined in the limitations section of this chapter, the IUSM OSCE was an inadequate proxy variable for simulation performance. A revised proxy variable for simulation performance should come from direct observations of medical students

with real patients. Therefore, future iterations of this work could use preceptor ratings of performance in actual clinical settings to provide a better understanding of real-world applicability of HFPS. Using these ratings may also better allude to the transferability of HFPS experience to actual clinical practice.

A review of the available literature revealed reliable and valid rubrics for preceptor ratings of student performance for nursing education (Prion et al., 2015; Walsh, Seldomridge, & Badros, 2008) and pharmacy education (Zhou, Almutairi, Alsaid, Warholak, & Cooley, 2017). To support consistent evaluation of registered nurses by their preceptors, a 35-item tool was found to have excellent internal consistency (Cronbach's alpha of 0.92), was positively evaluated for face validity by six content experts in nursing education, accurately discriminated between junior-level baccalaureate nursing students and nursing faculty, and was found to be a practical assessment method for preceptors requiring approximately 10 minutes to complete (Prion et al., 2015). To evaluate pharmacy students, a preceptor assessment tool was evaluated for construct and content validity and reliability via student and item separation index and reliability coefficients from 435 observations (Zhou et al., 2017). The tool measured the same construct of interest, worked unidimensionally with local independence of items and monotonicity of scaling, had high reliability (the student reliability coefficient was .92), and differentiated PharmD students' abilities. However, the lack of reliable and validated preceptor evaluation rubrics for medical students indicates an area for future research.

Even with reliable and valid rubrics, preceptor scores may have considerable variability and leniency toward higher rankings (Colletti, 2000; Huang & Grigoryan, 2017). However, a longitudinal study investigated the validity of preceptor evaluations as

an assessment of clinical competence among 157 first-year medical students through graduation and found that mean clinical evaluation scores demonstrated validity coefficients large enough to support their use as part of an evaluation of medical student clinical performance (Ferguson & Kreiter, 2004). To enhance the quality of preceptor ratings, Walsh, Seldomridge, and Badros (2008) advised for a preceptor rubric to have fewer rather than many performance indicators, the indictors should have detailed descriptions of particular performance indices for each level to assist preceptors in making more realistic ratings, the indicators should include only those tasks and skills that the preceptors routinely perform so that they are confident when judging the students' performance, and levels of performance should differentiate the frequency and nature of interventions or omissions in student behaviors. The authors also recommended that preceptors should be given an orientation to the rubric, ideally in a face-to-face workshop, and faculty should provide immediate feedback to support the development of preceptors as evaluators and aid in improved precision of ratings. All of these best practices may be challenging to implement, as preceptors are physicians who also are juggling their clinical responsibilities with their teaching responsibilities.

The tendency for students to receive unrealistically high ratings from their preceptors may be due to the delivery of the evaluation. Colletti (2000) discovered that face-to-face delivery of evaluations contributed to grade inflation of 24 third-year medical students, particularly for those students with poorer performance. The author concluded that having the preceptor send the evaluations directly to the researcher conducting the study may circumvent grade inflation; the researcher can then provide a summary of performance based on the preceptor's evaluations directly to students.

The case study design and convenience sampling was also noted as a limitation in this study. Ideally, a more robust study design such as a randomized-controlled trial (RCT) would yield greater insight into the interactions between simulation performance, clinical self-efficacy, and actual competence. Reported RCT of simulation have seen positive impacts on student learning and perceptions (Grantcharov et al., 2004; Steadman et al., 2006). However, such study designs may expose a portion of students to inferior pedagogical methodologies and pose educational ethical considerations that must be addressed (Amin & Abdulghani, 2015). For instance, a crossover design may be best suited to investigate this research topic, which was unable to be implemented by the author in the present study. A multi-institutional study investigating the integration of HFPS into modern medical curricula will help to increase the sample size and external validity of using this pedagogic strategy as well. Long-term retention studies should be conducted, following the same students from medical school into residency training, and perhaps beyond, to provide a comprehensive understanding of specific simulation areas of improvement to aid in closing the gap in knowledge between academic preparation and practice (Fero et al., 2010).

Interprofessional education (IPE) is another area with immense opportunities for future directions. Some medical students experienced frustrating conditions in their IPE teams (see Chapter 6), however the reverse may also be true in that some nursing students may have been frustrated with their medical student team members. Future studies should investigate the qualitative commentary from both medical students and nursing students to obtain a holistic understanding of the complex team dynamics that surface while participating in IPE HFPS.

This study used self-reported measures of self-efficacy and an arbitrary simulation scoring method by faculty. Self-assessment was shown to be inaccurate and an inferior measurement strategy compared to external, objective assessments of competence in a systematic review of the literature (Davies et al., 2006). More quantifiable methods could be employed that directly target physiologic measures of confidence and anxiety, such as using galvanic skin response (GSR) recorders or salivary cortisol samples that have proven useful in previous research (Gorrindo, Chevalier, Goldfarb, Hoeppner, & Birnbaum, 2014; Lindholm & Cheatham, 1983; Nourbakhsh et al., 2012; Phitayakorn et al., 2015).

The amount and type of preparation employed prior to participating in HFPS was asked during the pilot study (see Chapter 4) and the medical student interviews (see Chapter 6). The most commonly cited method to prepare for HFPS was online research (in the form of descriptive articles and videos) and role-playing with peers, with the amount of time dedicated to these activities ranging from almost none to two or more hours. Interestingly, one second-year medical student commented that they actually did better on those simulations in which they prepared very little; this was because they kept a more open mind while participating in the simulation and created a more thorough differential diagnosis list, rather than focusing on the pathologies and presentations that they had studied prior to the simulation.

Preparation for HFPS is an ongoing inquiry. Recall from Chapter 4, Henneman et al. (2007) described providing (an unspecified number of) nursing students with reading assignments, guidelines on participating in the simulation, simulation objectives, and the patient case summary prior to students participating in HFPS. Another example from

nursing education asked 36 fourth-year baccalaureate nursing students to create concept

maps in preparation for HFPS (Daley, Beman, Morgan, Kennedy, & Sheriff, 2017). The

researchers found that compared to historical controls, those nursing students who created

concepts maps prior to HFPS demonstrated an increase in behaviors associated with

perceptual grasp of the situation (including context of the situation, the background of the

patient, and patient understanding), in addition to pathological knowledge of the patient's

presentation and the nursing care required. In pharmacy education research, Vyas and

colleagues (2010) gave fourth-year pharmacy students a case preparation period which

required them to complete a pre-simulation quiz individually, then review the patient's

history and physical findings and work as a team in order to develop a treatment plan.

Although the researchers did not assess the pre-simulation work specifically, they did

discover that those pharmacy students who participated in HFPS demonstrated

statistically significant higher knowledge retention and felt more confident making

recommendations to other healthcare providers compared to a control group of pharmacy

students who were not exposed to HFPS. With the apparent lack of research regarding

preparation for HFPS in medical education, this is a potential avenue for future

investigations.

Specifically related to Q-methodology, a repeated measures (pairwise) Q-

methodology study design using longitudinal, temporally spaced data within the same

group may elicit altering changes in viewpoints over time. Additionally, Q-sorts can be

compared between two different populations, as recommended by Block (1994). For

instance, comparing Q-sorts between medical students and medical residents exposed to

HFPS, or comparing Q-sorts between an intervention group exposed to HFPS with a

control group not exposed to HFPS can provide more insight about an intervention. Given the improved response time achieved by using an electronic Q-methodology sorting program discovered in this dissertation research, a study design incorporating various student populations appears achievable.

Low response rates permeated this research. Future endeavors should capitalize on best practices and recommendations for obtaining maximum response rates outlined by Kochhar (2017): the first follow-up email should be sent two weeks after the initial survey distribution with the subject of the email including the following text: "this is the first follow-up email;" this is followed by a second follow-up email one week later with the subject stating "this the second follow-up email;" finally, one week after the second follow-up email (and 5 weeks after the initial survey administration), the third and final follow-up email should be sent with the subject stating "This is the third and final follow-up."

However, it is important to consider that a greater response rate may not necessarily dictate quality data. Scores were found to deviate less on average with a smaller sample with respect to the confidence interval size (Royal, 2016a, 2016b). Additionally, low response rates have been shown to poorly correlate with response bias (Groves, 2006; Groves & Peytcheva, 2008).

Further questions regarding HFPS include: how does experiencing several HFPS impact learning, or is there a saturation point? Is a particular concept or topic better addressed through HFPS than others? What is the long-term effect of this intervention? Are there other methods of evaluation to better understand student perception? Additionally, Harris (2016) poses questions such as: When should students be exposed to

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simulation? How often should students experience simulations? What types of simulation are most effective? Does HFPS show longer-term retention in knowledge and skills than other modalities? Could a less expensive alternative such as Standardized Patients (SPs) replace HFPS? Do benefits of HFPS outweigh the cost and effort of implementing this pedagogy (i.e., is there an adequate return on investment (ROI) with this method of instruction)? What are students actually obtaining from simulation, especially given the large investment needed to initially construct a high-fidelity simulation center, and the ongoing cost to maintain equipment and train staff? Coombs et al. (2017) also concluded that future study designs should compare educational impact against a "cost evaluation framework" (p. 499) to evaluate the pedagogical return on investment.

With all of these lingering questions and potential directions for future research, one salient fact remains: that HFPS is likely here to stay and thus requires continued research. Given the scant research currently available that attempts to directly investigate the impact of HFPS on learning outcomes, this dissertation research does add to the existing evidence, yet highlights the need for additional rigorous research. As Scalese and colleagues (2007) summarized, "spanning the continuum of educational levels and bridging multiple health care professions, medical simulations are increasingly finding a place among our tools for teaching and assessment" (p. 48).

Part V: Final Conclusions

Anderson and colleagues (2008) humorously stated, "Simulation is sexy" (p. 595). Does this expensive, flashy learning strategy convey tangible benefits to students? The results from this research allude to the answer: yes.

Medical students at IUSM-B acquired practice, experience, and lifesaving skills sooner than their peers attending other IUSM campuses, a perception shared by IUSM-B students as well as faculty and staff who worked with IUSM medical students. Given the innate desire to protect the safety of patients, is it considered unethical to expose IUSM-B medical students to HFPS and not medical students at the other IUSM campuses?

This dissertation research exemplified the continued momentum and strengthens the existing evidence related to the discovery of the extent of using HFPS as a tool for developing competent, professional physicians to respond to the needs of an increasingly complex healthcare environment. It is important to note that definitive conclusions cannot be drawn based on the results of this research alone. Rather, this dissertation aimed to articulate one more data point in the overall discussion of HFPS as a useful educational intervention. The quantitative and qualitative results and conclusions of this work supports, and advocates for, the construction and thoughtful integration (beginning in the first year of medical training) of HFPS centers across all IUSM campuses in order to equip medical students with the innate ability to competently care for patients as soon as they walk across the hospital threshold.

APPENDIX A: MEDICAL STUDENT SELF-EFFICACY AND SIMULATION

PERCEPTION QUESTIONNAIRE — INTERVENTION GROUP

Thank you for your participation in this questionnaire examining the clinical self-efficacy of medical students. Your information will be kept confidential and will be unable to be linked back to you after deidentification. Your participation in this questionnaire is voluntary and you may withdraw from this study at any time. Please be aware that completion of this questionnaire grants the researcher permission to acquire performance-based scores (for example, the H&P or OSCE) to link to this record, which will be subsequently deidentified.

Upon submission of this questionnaire you will be entered into a random drawing for a $100 Amazon gift card. Feel free to contact the researcher with any questions: Barbie Klein, barbklei@indiana.edu.

 (note: all information will be completely deidentfied after pairing with participant's record)

     ○ Last Name   _____

     ○ First Name   _____

     ○ IUSM ID #   _____

 Which IUSM campus do you currently attend?

     ○ Bloomington

     ○ Evansville

     ○ Fort Wayne

Section 1: Appraisal Inventory
The following questions list various activities required during patient encounters.
Please slide each scale to rate your ability to successfully complete the following tasks in
a hospital or clinical setting <u>at this time</u> in your medical career.

Q1 Patient interview and medical history

Interview a patient about their chief complaint in a hospital or clinical setting	
Accurately document a patient's medical history	

Q2 Physical and diagnostic examination

Perform a physical examination in a hospital or clinical setting	
Interpret findings from a physical examination	
Order appropriate diagnostic tests	
Interpret results from diagnostic tests	

Q3 Application of knowledge

Integrate relevant basic science knowledge to the patient's presentation	
Create a list of appropriate differential diagnoses	
Generate a treatment plan	

Q4 Interpersonal skills and communication

Clearly communicate with other members of the healthcare team about a patient case	
Explain the reasoning of what is likely causing the primary complaint to a patient	
Connect with patients and verify patient understanding	

Q5 <u>At this time</u> in your medical career, how would you rate your overall ability as a clinician?

○ Novice (must follow specific rules; filtering or prioritizing information is difficult; requires maximum guidance)

○ Advanced beginner (less dependent on a mentor but still requires guidance and rules; able to filter and sort information)

○ Competent (comfortable with tasks from past experience; less dependent on rules; can adjust actions according to current situation; still relies on structured procedures for novel situations)

○ Proficient (less rule-driven; more comfortable and flexible with novel situations; recognizes patterns)

○ Expert (responds to situations quickly and intuitively; can anticipate future situations and the unexpected)

○ Master (expert who no longer needs principles; effortlessly recognizes subtle features; self-regulated and reflective)

Section 2: Perceptions and Demographics

Q6 Please rank by dragging and dropping the following strategies for learning clinical skills in order of your preference from most helpful to learn from to the least helpful.

1 = Most helpful for learning clinical skills
5 = Least helpful for learning clinical skills

_____ Computer-based modules
_____ Standardized Patients (real actors trained to play a patient)
_____ Real patients
_____ Part-task trainers (for example, small groups learning around a part-task trainer such as Harvey® Cardiopulmonary Simulator)
_____ High-fidelity simulations (realistic room and responsive manikins)

Q7 Which of the following, if any, did you find <u>most</u> beneficial about participating in simulations at the IUSM Bloomington Simulation Center?

○ Ability for repeated practice

○ Exposure to a wide variety of patient cases

○ Debriefing with a faculty member after the simulation

○ Opportunities to integrate basic science knowledge with clinical practice

○ Working with nursing students during interprofessional education (IPE) simulations

○ I did not find simulation beneficial to my medical education

○ Other. Please describe.

_____

Q8 How prepared do you feel to successfully complete your upcoming performance-based assessment (OSCE or H&P exam)?

○ Completely unprepared

○ Moderately unprepared

○ Slightly unprepared

○ Slightly prepared

○ Moderately prepared

○ Very well prepared

Q9 What are your overall impressions about your experience participating in simulations at the IUSM Bloomington Simulation Center during your medical education?

_____

_____

_____

_____

Q10 What is your current year in medical school?

○ First

○ Second

○ Third

○ Fourth

Q11 (note: all information will be completely deidentfied after pairing with participant's record)

   ○ What is your age in years?

     _____

   ○ How do you describe your ethnicity?

     _____

   ○ How do you describe your gender?

     _____

Q12 Would you be willing to participate in a brief follow-up interview regarding your testing experience and overall reflections of the effectiveness of your clinical training?

   ○ Yes (please enter your preferred contact email)

     _____

   ○ No

Q13 Thank you for completing this questionnaire and helping to improve medical education! If you would like to be entered into the drawing for a $100 Amazon.com gift card, please enter your preferred contact email. Winners will be notified via email in August.

End of Block

APPENDIX B: MEDICAL STUDENT SELF-EFFICACY AND SIMULATION

PERCEPTION QUESTIONNAIRE — CONTROL GROUP

Thank you for your participation in this questionnaire examining the clinical self-efficacy of medical students. Your information will be kept confidential and will be unable to be linked back to you after deidentification. Your participation in this questionnaire is voluntary and you may withdraw from this study at any time. Please be aware that completion of this questionnaire grants the researcher permission to acquire performance-based scores (for example, the H&P or OSCE) to link to this record, which will be subsequently deidentified.

Upon submission of this questionnaire you will be entered into a random drawing for a $100 Amazon gift card. Feel free to contact the researcher with any questions: Barbie Klein, barbklei@indiana.edu.

 (note: all information will be completely deidentfied after pairing with participant's record)

○ Last Name   _____

○ First Name   _____

○ IUSM ID #   _____

 Which IUSM campus do you currently attend?

○ Bloomington

○ Evansville

○ Fort Wayne

Section 1: Appraisal Inventory
The following questions list various activities required during patient encounters.
Please slide each scale to rate your ability to successfully complete the following tasks in
a hospital or clinical setting <u>at this time</u> in your medical career.

Q1 Patient interview and medical history

Interview a patient about their chief complaint in a hospital or clinical setting	
Accurately document a patient's medical history	

Q2 Physical and diagnostic examination

Perform a physical examination in a hospital or clinical setting	
Interpret findings from a physical examination	
Order appropriate diagnostic tests	
Interpret results from diagnostic tests	

Q3 Application of knowledge

Integrate relevant basic science knowledge to the patient's presentation	
Create a list of appropriate differential diagnoses	
Generate a treatment plan	

Q4 Interpersonal skills and communication

Clearly communicate with other members of the healthcare team about a patient case	
Explain the reasoning of what is likely causing the primary complaint to a patient	
Connect with patients and verify patient understanding	

Q5 <u>At this time</u> in your medical career, how would you rate your overall ability as a clinician?

○ Novice (must follow specific rules; filtering or prioritizing information is difficult; requires maximum guidance)

○ Advanced beginner (less dependent on a mentor but still requires guidance and rules; able to filter and sort information)

○ Competent (comfortable with tasks from past experience; less dependent on rules; can adjust actions according to current situation; still relies on structured procedures for novel situations)

○ Proficient (less rule-driven; more comfortable and flexible with novel situations; recognizes patterns)

○ Expert (responds to situations quickly and intuitively; can anticipate future situations and the unexpected)

○ Master (expert who no longer needs principles; effortlessly recognizes subtle features; self-regulated and reflective)

Section 2: Perceptions and Demographics

Q6 Please rank by dragging and dropping the following strategies for learning clinical skills in order of your preference from most helpful to learn from to the least helpful.

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_____ Computer-based modules
_____ Standardized Patients (real actors trained to play a patient)
_____ Real patients
_____ Part-task trainers (for example, small groups learning around a part-task trainer such as Harvey® Cardiopulmonary Simulator)
_____ High-fidelity simulations (realistic room and responsive manikins)

Q7 How prepared do you feel to successfully complete your upcoming performance-based assessment (OSCE or H&P exam)?

○ Completely unprepared

○ Moderately unprepared

○ Slightly unprepared

○ Slightly prepared

○ Moderately prepared

○ Very well prepared

Q8 What is your current year in medical school?

○ First

○ Second

○ Third

○ Fourth

Q9 (note: all information will be completely deidentfied after pairing with participant's record)

○ What is your age in years?

_____

○ How do you describe your ethnicity?

_____

○ How do you describe your gender?

_____

Q10 Would you be willing to participate in a brief follow-up interview regarding your testing experience and overall reflections of the effectiveness of your clinical training?

○ Yes (please enter your preferred contact email)

_____

○ No

Q10 Thank you for completing this questionnaire and helping to improve medical education! If you would like to be entered into the drawing for a $100 Amazon.com gift card, please enter your preferred contact email. Winners will be notified via email in August.

End of Block

APPENDIX C: FIRST-YEAR, SECOND-YEAR, AND THIRD-YEAR MEDICAL

STUDENT STUDY INFORMATION SHEET

INDIANA UNIVERSITY STUDY INFORMATION SHEET FOR

Medical Student Perceptions of Clinical Self-Efficacy

You are invited to participate in a research study investigating how simulated clinical practice influences perceived ability. Please read this form and ask any questions you may have before agreeing to be in the study. The study is being conducted by Dr. Valerie O'Loughlin and Barbie Klein from Medical Sciences at Indiana University Bloomington. Currently, there is no funding or sponsor for this study.

STUDY PURPOSE
The purpose of this study aims to discover if simulation-based medical education (SBME) fosters accurate self-appraisal of clinical ability among medical students. Additionally, this study will investigate to what extent participating in high-fidelity simulation (HFS) influences perceived self-efficacy and clinical competence. The overall goal of this research is to generate a broad understanding of the role of simulated learning in attaining clinical self-efficacy and how this impacts performance.

PROCEDURES FOR THE STUDY:
If you agree to be in the study, you will do the following:

- Complete one online survey about your self-efficacy perceptions and general demographic data

- Submission of the questionnaire will signify acceptance of the data pairing procedure required for this research

- Upon submission of the questionnaire you will be entered into a random drawing for a $100 Amazon gift card

CONFIDENTIALITY
Please be aware that completion of this questionnaire grants the researcher permission to acquire performance-based scores (e.g., the H&P or OSCE) to link to the record, which will be subsequently deidentified. Your information will be kept confidential and will be unable to be linked back to you after deidentification. Your identity will be held in confidence in reports in which the study may be published and databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP).

PAYMENT
You will not receive payment for taking part in this study, however upon successful submission of the questionnaire you will be entered into a random drawing for a $100 Amazon gift card.

CONTACTS FOR QUESTIONS OR PROBLEMS
For questions about the study, contact the researcher, Barbie Klein, at [phone number] or Valerie O'Loughlin at [phone number].

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (317) 274-8289 or [for Indianapolis] or (812) 856-4242 [for Bloomington].

VOLUNTARY NATURE OF STUDY
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University or the School of Medicine.

Form date: October 28, 2016

APPENDIX D: SIMULATION CENTER FLOOR PLANS

Indiana University Bloomington Simulation Center (IUSM-BL)
Source: http://floorplans.service.indiana.edu/dwn_plan.cfm?what=1
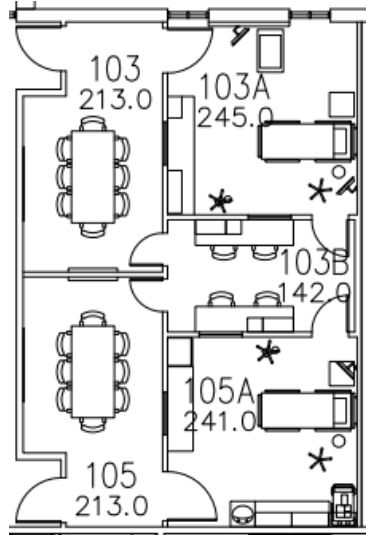
The Simulation Center at Fairbanks Hall (IUPUI)
Source: http://iuhealth.org/sim-center/floor-plan/
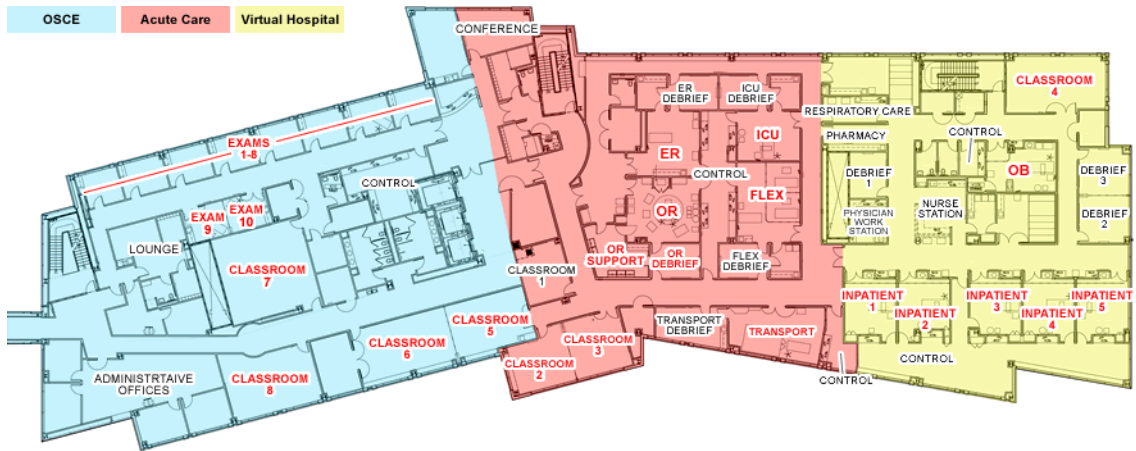
APPENDIX E: FIRST-YEAR, SECOND-YEAR, AND THIRD-YEAR MEDICAL

STUDENT INTERVIEW QUESTIONS

1. You recently took the OSCE and indicated on your survey that you felt
   [PREPAREDNESS RESPONSE]. Now after taking the exam, what are your
   impressions regarding your performance?
   a. INTERVENTION ONLY: Do you feel that participating in simulated
      experiences sufficiently prepare you for the OSCE, or was there
      something else that better prepared you?
2. How did you typically prepare for the OSCE at your campus?
3. The survey asked you to rank strategies to learn clinical skills according to your
   preference. Can you elaborate on your rankings?
   a. Did SPs ever give contradictory advice from each other or from your
      program's recommendations?
4. CONTROL ONLY: Did you ever get a chance to practice in a simulation center?
   a. Are you aware of the simulation center at the Bloomington campus?
   b. Given that this campus has this resource and yours does not, do you feel
      that you were at a disadvantage compared to the students at the
      Bloomington campus?
5. CONTROL ONLY: Did you ever get a chance to work with the nursing students
   at your campus as a healthcare team?
6. There was a question on the survey asking you to rate your overall ability as a
   physician at this time in your medical career. Can you elaborate on your choice of
   [DREYFUS RESPONSE]?
7. Do you have any recommendations for how clinical skills are taught in your
   medical program at your campus?
8. INTERVENTION ONLY:
   a. What are your thoughts about your simulation experience at the IUSM-B?
   b. What, if anything, do you believe you learned in simulations that can be
      applied to your clinical practice?
   c. What are your impressions with the realism achieved, or lack there of, in

the simulation center?

d. Did you ever find it difficult to participate in simulations?

e. How did you typically prepare for participating in simulations?

f. Do you believe that you had sufficient opportunities to participate in simulations, or would you desire more or less simulation experiences?

g. Do you have any recommendations for how future simulations are conducted in the simulation center?

APPENDIX F: MEDICAL RESIDENT STUDY INFORMATION SHEET

INDIANA UNIVERSITY STUDY INFORMATION SHEET FOR

Q Study of Graduates' Beliefs Regarding Simulation-based Medical Education

You are invited to participate in a research study investigating how simulated clinical practice influences perceived ability. Please read this form and ask any questions you may have before agreeing to be in the study. The study is being conducted by Dr. Valerie O'Loughlin and Barbie Klein from Medical Sciences at Indiana University Bloomington. Currently, there is no funding or sponsor for this study.

STUDY PURPOSE

This research study examines the attitudes and beliefs of graduates who have experienced simulation-based medical education (SBME) to discover how simulation impacts future clinical practice. The overall goal of this dissertation research is to generate a broad understanding of the role of simulated learning in attaining clinical self-efficacy and how this impacts performance. Results from participants will be correlated and factor analysis will reveal clusters of people with similar and differing views (known as a Q study).

PROCEDURES FOR THE STUDY:

If you agree to be in the study, you will do the following:

- Complete one online statement sorting procedure regarding your attitudes about medical simulation

- Upon submission of the sorted statements you will be entered into a random drawing for a $100 Amazon gift card

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. Your identity will be held in confidence in reports in which the study may be published and databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP).

PAYMENT

You will not receive payment for taking part in this study, however upon successful submission of the sorted statements you will be entered into a random drawing for a $100 Amazon gift card.

CONTACTS FOR QUESTIONS OR PROBLEMS

For questions about the study, contact the researcher, Barbie Klein, at [phone number] or Valerie O'Loughlin at [phone number].

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (317) 274-8289 or [for Indianapolis] or (812) 856-4242 [for Bloomington].

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University or the School of Medicine.

Form date: October 30, 2016

Q Sorting Instructions

This research study asks "How do medical graduates perceive high-fidelity patient simulation (HFPS) experienced during their medical education?" The purpose of this study is to understand the role and impact of high-fidelity patient simulation in medical education with the goal of identifying the most and least beneficial components of the simulation experience to their current careers as physicians. These instructions will guide you step-by-step through this portion of the study. Please read each step before you begin.

For this pilot study, please cut out the Q sort statement cards (35 total). (Note: participants during the actual Q study will be conducting the sorting process online). All 35 cards in the deck contain a statement about simulation in medical education. Each card has a number on it; this number is not significant to the statement but to make it easy to place the statement on the sorting sheet.

1. Please order these statements according to how important they are to you. There are no right or wrong answers, these are just your opinions. To begin, please read the statements carefully and split them up into 3 piles:
    - One pile for cards you feel are important
    - One pile for the cards you feel are not important
    - One pile for cards you feel are neither important nor not important, are uncertain of, or feel that do not apply to you

2. Next, look at the sorting table and notice that there are 35 boxes for the 35 cards. Follow these directions to place each of the 35 statements into a box on the sorting sheet:
    a. Take the cards from the "IMPORTANT" pile and read them again. Select the 2 statements you think are MOST important and write or type the numbers of the cards in the 2 boxes within the grid on the right of the Sorting Sheet below the "+4" (it does not matter which one goes on top). You will write one number corresponding to the card in each of the boxes below the "+4".
    b. Now, from the remaining cards in the "IMPORTANT" pile, select the 3 statements you think are most important and place their numbers in the 3 boxes below the "+3". Again, you will write one number for each box and the order of the numbers within each column does not matter.
    c. You will do this same thing again from the remaining cards in the "IMPORTANT" pile, select the 4 statements you think are most important and write the numbers in the 4 boxes below the "+2". You will continue this process moving right to left filling each column until all of the cards from the "IMPORTANT" pile are gone.

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3. Now take the cards from the "NOT IMPORTANT" pile and read them again. Just like before, select the 2 statements you think are "NOT IMPORTANT" and write their numbers in the 2 boxes on the left of the Sorting Sheet grid below "-4." One number for each box. You will continue this procedure from the remaining "NOT IMPORTANT" pile by picking the next 3 cards you feel are most unimportant. Write their numbers in the boxes under the "-3" with only one number in each box. From the remaining "NOT IMPORTANT" pile, pick the next 4 cards you feel are unimportant. Write their numbers in the boxes under the "-2" with only one number in each box. You will continue this process moving left to right filling each column until all of the cards from the "NOT IMPORTANT" pile are gone.

4. Finally, take the remaining "Neutral" cards and read them again. Write the numbers of these cards in any remaining open spaces.

5. When you have written all the numbers of the cards on the Sorting Sheet and all the boxes are filled, please go over your choices once more and make any changes if you want to.

6. Once you have completed recording your selections please briefly answer the open-ended questions under Step 3 on the Sorting Sheet and email the document back to Barbie Klein at [email].

7. If you have further questions, comments, or concerns after you've finished the procedure, you may contact Barbie Klein at [email] or [phone number].

Q-Sort Scoring Sheet

Not Important Pile   Neutral / Not Relevant Pile   Important Pile

STEP 2: Read Steps 2, 3, and 4 of the instructions and write in the number of each statement within the boxes below.

Strongly Disagree   Neutral   Strongly Agree

-4   -3   -2   -1   0   +1   +2   +3   +4

Please provide feedback on the following questions.
1. Were the instructions clear? If not please explain.

2. How long did it take you to complete the sort?

3. Was any statement unclear? If so please explain.

4. Did any statements seem to be repetitive? If so please explain.

5. Were there any best practices in simulation that were not included in the statements? If so please make suggestions.

6. Did you feel that all of the statements addressed the research question and goal? If not please explain.

7. Please add any other feedback you feel would help improve this study.

1 Simulations provided me with an opportunity to actively use my knowledge rather than just memorize facts	**2** It was difficult to believe that a plastic, immobile manikin was a real patient	**3** Participating in simulations helped me learn from my mistakes
4 Participating in simulations improved my critical thinking skills	**5** It was difficult to believe that the simulations were real	**6** Simulations helped me learn to think quickly under pressure
7 More simulations should have been offered during my medical education	**8** Simulations were predictable	**9** I feel more prepared to think clinically after participating in simulations
10 Simulations were better for reviewing material rather than learning new material	**11** Simulations were difficult to learn from	**12** Simulations provided an opportunity for me to develop my routine
13 Simulations exposed me to diverse scenarios that I may not have otherwise had the opportunity to experience before working with real patients	**14** I felt anxiety knowing that I was being recorded while participating in simulations	**15** Simulations provided an opportunity to practice organizing my thoughts
16 Simulations feel more like a game than studying	**17** I knew basic science material from class better after practically applying it in simulations	**18** I believe that my clinical skills are better compared to those who do not experience simulation

19 Simulations improved my communication skills	**20** I easily transferred my knowledge learned during simulations to clinical settings	**21** Simulation provides opportunities to practice how skills are performed
22 Simulations helped me learn how to work in a multidisciplinary team	**23** I think simulations should be used as a teaching tool rather than as an evaluation tool	**24** The immersive, hands-on simulation environment is worth the expense to build and maintain
25 I developed the ability to communicate with patients and their families after participating in simulations	**26** Simulations increase your awareness of your actual ability	**27** Physically interacting with the environment in the simulation center helped me remember things better
28 It was helpful to have someone who works in the field debrief with us after the simulations	**29** Simulations highlighted areas I needed to improve upon before working with real patients	**30** I preferred training with interactive manikins (simulators) rather than standardized patients (SPs)
31 Immediate feedback during the debrief after the simulations improved my learning	**32** The practice during simulations minimized my anxiety when helping real patients	**33** Simulators are a valuable teaching tool with which I would like to have further experience
34 Simulations can replace clinical experience in the real world	**35** Participating in simulations made me feel more confident as a physician	

APPENDIX H: FINAL Q-SAMPLE STATEMENTS WITH REFERENCES

Final Q-sample – 37 statements

Active learning/critical thinking
• Simulations gave me a chance to practically apply knowledge learned in class (Ha 2016)

• Participating in simulations improved my critical thinking skills (Landeen 2015)

Amount/types of simulations offered
• More simulations should have been offered during my medical education (MS2 interview pilot study)

• Simulations were better for reviewing material rather than learning new material (Ha 2016)

• Simulations exposed me to diverse patient scenarios (Ha 2016; Sheakley 2016)

• Simulations created a fun environment to learn (interview MS2-04)

Communication/IPE
• Simulations improved my communication skills with other healthcare providers (Landeen 2015)

• Simulations improved my communication skills with patients (Ha 2016)

• The IPE simulations with the nursing students helped me learn how to work in a multidisciplinary team (Baxter 2009)

Debrief
• The debrief after simulations is the most important component of a simulation-based learning experience (Decker 2013)

Simulation drawbacks/disadvantages
• It was difficult to believe that a manikin was a real patient (Baxter 2009)

• Simulation-based training can replace clinical experience in the real world (Wallenburg, 2010)

• It was difficult to relate the simulations to reality (MS2 interview pilot study)

- Simulations were predictable (MS2 interview pilot study)

- It was difficult to learn during simulations (Ha 2016)

- Simulations were stressful because it felt as though I was on a stage (O'Regan 2017; Yeun, 2014)

- I could not concentrate during simulations because I was conscious of being recorded (Ha 2014)

- Simulations were less helpful because of the anxiety that they created (MS2 interview pilot study)

Integration/Transfer
- I was able to easily transfer what I learned during simulations to real clinical settings (Landeen 2015)

- I think simulations should be used for teaching rather than for evaluating my performance (Morgan 2000)

- Simulations should be used beginning in the first year of medical school (Yeun, 2014)

Metacognition
- Simulations increased my awareness of my actual ability (Baxter 2009)

Practice/preparation/confidence
- The practice during simulations decreased my anxiety when helping real patients (Baxter 2009)

- Participating in simulations made me feel more confident (Ha 2016)

- Participating in simulations helped me learn from my mistakes (Landeen 2015)

- Simulations helped me learn to think quickly under pressure (MS2 interview pilot study)

- Participating in simulations helped me develop my routine (MS2 interview pilot study)

- Participating in simulations prepared me to work independently (Berkhout 2017)

- Participating in simulations prepared me to concentrate in a hectic clinical environment (Berkhout 2017)

- Simulation training improves patient safety (Fokkema 2014; Wallenburg 2010)

Skill acquisition

- Simulations allowed me to practice how clinical skills are performed (Baxter 2009)

- Simulations prepared me to recognize emergency (life-threatening) situations (Meade 2013)

- Simulations are effective because residents learn by doing (Wallenburg 2010)

Fidelity/sim center architecture

- The immersive, hands-on simulation environment is worth the expense to build and maintain (MS2 interview pilot study)

- Physically interacting with the environment in the simulation center helped me remember things better (MS2 interview pilot study)

- I preferred training with interactive manikins (simulators) rather than Standardized Patients (SPs) (MS2 interview pilot study)

- Effective simulations require a well-trained operator/coordinator (MS2 interview pilot study)

APPENDIX I: INTERVIEW QUESTIONS FOR PILOT STUDY OF SECOND-YEAR

MEDICAL STUDENTS

1. What have you found most beneficial about simulation?

2. What recommendations would you suggest for future simulations?

3. How did you prepare prior to participating in simulations?

4. What are your impressions with the technology used in the simulation lab?

5. Did the interactive manikins greatly improve your learning? Do you feel that you would have gotten the same benefits from a computer-based simulation?

6. What are you impressions regarding the number of simulations offered to you?

7. Do you have any advice for future first year medical students before they participate in simulations?

APPENDIX J: STUDY CONSENT FORM FOR PILOT STUDY OF SECOND-YEAR

MEDICAL STUDENTS

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT FOR

Second-Year Medical Student Perceptions of VoiceThread and Simulation Laboratory Experience

STUDY PURPOSE

You are invited to participate in a research study that seeks to examine medical student perceptions of VoiceThread, a peer-teaching intervention, and perceptions of the first two years of patient simulation experiences within the simulation laboratory. You were selected as a possible subject because you participated in creating and viewing VoiceThread presentations during A550-551 Gross Human Anatomy and participated in patient simulations throughout the first two years of medical school at Indiana University Bloomington. Please read this form and ask any questions that you may have before agreeing to be in the study.

The study is being conducted by Barbie Klein, Stacey Dunham, and Valerie O'Loughlin (all researchers from Medical Sciences). There is no funding for this study.

PROCEDURES FOR THE STUDY

Medical students who agree to participate in the study, by signing this informed consent document, will allow the investigators to conduct short interviews regarding their perceptions of two teaching interventions: VoiceThread and patient simulations. If consent is obtained, the researchers may contact you at a later date to clarify statements or ask for additional information.

RISKS OF TAKING PART IN THE STUDY

There are no foreseeable risks associated with this study.

BENEFITS OF TAKING PART IN THE STUDY

By participating in this study, you will help the investigators determine how course interventions influence medical student development as healthcare providers. The researchers will analyze the results of the interviews to influence future instructional interventions, and in so doing, you will help future medical students.

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. Your identity will be held in confidence in reports in which the study may be published and databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP).

PAYMENT

You will not receive payment for taking part in this study.

CONTACTS FOR QUESTIONS OR PROBLEMS

If you have questions at any time about the study or the procedures, you may contact the investigators: Barbie Klein, Jordan Hall 109A, [phone number], [email], or Stacey Dunham, Jordan Hall 109A, [phone number], [email].

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (812) 856-4242 or (800) 696-2949.

VOLUNTARY NATURE OF STUDY

Your participation in this study is voluntary; you may decline to participate without penalty. Your grades will not be influenced by whether or not you choose to participate. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed, your data will not be used in this study.

SUBJECT'S CONSENT

	Yes	No
I have read this form and received a copy of it. I have had all my questions answered to my satisfaction. I agree to take part in this study.	☐	☐
I agree to be contacted at a later date to verify interview information or answer additional questions.	☐	☐
I would like to be notified of the study results.	☐	☐

Subject's Printed Name:_____

Subject's Signature:_____**Date**:_____
(must be dated by subject)

Subject's email address: _____
(if you agreed to be contacted for transcript clarification or possible follow-up questions)

Form Date 04/20/2016   2

APPENDIX K: MEDICAL RESIDENT Q-STUDY POST-SORT INTERVIEW

QUESTIONS

1. Can you elaborate on the reasoning behind your most agree (+4) statements?

2. Can you elaborate on the reasoning behind your most disagree (-4) statements?

3. What, if anything, do you believe you learned in simulation can be applied to your

   clinical practice?

4. What do you believe was the most important aspect of simulation?

5. Please describe your impression of the following simulation aspects:

   a. Immersive environment

   b. High-fidelity patient manikins

   c. Debrief

   d. IPE

6. What do you think could have been done to improve your simulation experience

   during medical school?

7. Do you still participate in HFPS as part of your continuing medical education?

8. Do you have any advice or recommendations for current medical students

   regarding their simulation experience?

APPENDIX L: FACULTY AND STAFF INTERVIEW STUDY INFORMATION

SHEET

INDIANA UNIVERSITY STUDY INFORMATION SHEET FOR

Faculty and Staff Interviews Regarding Simulation-based Medical Education

You are invited to participate in a research study examining the attitudes and beliefs of faculty and staff associated with simulation-based medical education (SBME). Please read this form and ask any questions that you may have before agreeing to be in the study. The study is being conducted by Dr. Valerie O'Loughlin and Barbie Klein from Medical Sciences at Indiana University Bloomington. There is no funding or sponsor for this study.

STUDY PURPOSE

This research study examines the attitudes and beliefs of faculty and staff associated with simulation-based medical education (SBME) to discover how high-fidelity patient simulation (HFPS) impacts their instruction and how they believe simulation impacts the future clinical practice of their students. The overall goal of this dissertation research is to generate a broad understanding of the role of simulated learning in attaining clinical self-efficacy and how this affects performance.

PROCEDURES FOR THE STUDY:

If you agree to be in the study, you will do the following:

* Participate in one in-person or phone interview

* The interview should last approximately 15-20 minutes

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. Your identity will be held in confidence in reports in which the study may be published and databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP).

PAYMENT

You will not receive payment for taking part in this study.

CONTACTS FOR QUESTIONS OR PROBLEMS

For questions about the study, contact the researcher, Barbie Klein at [phone number], or Valerie O'Loughlin at [phone number].

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (317) 274-8289 or [for Indianapolis] or (812) 856-4242 [for Bloomington].

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University or the School of Medicine.

Form date: September 13, 2017

REFERENCES

AAMC. (2007). Effective use of educational technology in medical education – Colloquium on educational technology: Recommendations and guidelines for medical educators. *AAMC Institute for Improving Medical Education*, 1–18.

"AAMC SP/OSCE Final Examinations at US Medical Schools." (2018). Retrieved from https://www.aamc.org/initiatives/cir/406426/9.html.

Abdulwahed, M. & Nagy, Z. (2009). Applying Kolb's experiential learning cycle for laboratory education. *Journal of Engineering Education*, *98*(3), 283–294.

Abrahamson, S., Denson, J., & Wolf, R. (1969). Effectiveness of a simulator in training anesthesiology residents. *Journal of Medical Education*, *44*, 515–519.

Ackermann, A. (2009). Investigation of learning outcomes for the acquisition and retention of CPR knowledge and skills learned with the use of high-fidelity simulation. *Clinical Simulation in Nursing*, *5*, 213–222.

Ahmed, A., Abid, M., & Bhatti, N. (2017). Balancing standardized testing with personalized training in surgery. *Advances in Medical Education and Practice*, *8*, 25–29.

Ahmed, M., Arora, S., Russ, S., Darzi, A., Vincent, C., & Sevdalis, N. (2013). Operation debrief: A SHARP improvement in performance feedback in the operating room. *Annals of Surgery*, *258*(6), 958–963.

Akhtar-Danesh, N., Baumann, A., & Cordingley, L. (2008). Q-Methodology in nursing research: A promising method for the study of subjectivity. *Western Journal of Nursing Research*, *30*(6), 759-773.

Akhtar-Danesh, N., Baxter, P., Valaitis, R., Stanyon, W., & Sproul, S. (2009). Nurse faculty perceptions of simulation use in nursing education. *Western Journal of Nursing Research*, *31*(3), 312–329.

Akhtar-Danesh, N. (2016). An overview of the statistical techniques in Q Methodology: Is there a better way of doing Q analysis? *Operant Subjectivity: The International Journal of Q Methodology*, *38*(3/4), 29–36.

Alghamdi, K., Katib, B., Alhoqail, A., & Al-khatib, T. (2016). Perception and acceptance of senior medical students at King Abdulaziz University of the use of Objective Structured Clinical Examination as a tool of assessment. *AMEE MedEdPublish*, doi: 10.15694/mep.2016.000074

Alinier, G., Hunt, B., Gordon, R., & Harwood, C. (2006). Effectiveness of intermediate-fidelity simulation training technology in undergraduate nursing education. *Issues and Innovations in Nursing Education*, *54*(3), 359–369.

Alinier, G. (2011). Developing high-fidelity health care simulation scenarios: A guide for educators and professionals. *Simulation & Gaming*, *42*(1), 9–26.

Alluri, R., Tsing, P., Lee, E., & Napolitano, J. (2016). A randomized controlled trial of high-fidelity simulation versus lecture-based education in preclinical medical students. *Medical Teacher*, *38*, 404–409.

Alvin, M. (2016). The USMLE Step 2 CS: Time for a change. *Medical Teacher*, *38*(8), 854–856.

Ambrose, S., Bridges, M., DiPietro, M., Norman, M., Lovett, M., & Norman, M. (2010). How learning works: 7 research-based principles for smart teaching. San Francisco: Jossey-Bass, A Wiley Imprint.

Amin, Z. & Abdulghani, M. (2015). Research methods in anatomy education. DiLullo, C. (2015). Learners of a new generation. In Chan, L. & Pawlina, W. (Eds.), *Teaching anatomy: A practical guide* (pp. 383–389). New York: Springer.

Anderson, J., Aylor, M., & Leonard, D. (2008). Instructional design dogma: Creating planned learning experiences in simulation. *Journal of Critical Care*, 23, 595–602.

Arnold, L., Willoughby, L., & Calkins, V. (1985). Self-evaluation in undergraduate medical education: A longitudinal perspective. *Journal of Medical Education*, *60*, 21–28.

Artino, A., Durning, S., & Creel, A. (2010). AM last page: Reliability and validity in educational measurement. In Association of American Medical Colleges (AAMC), Academic Medicine Last Pages: An Infographic Collection. Washington, D.C. p. 48.

Badash, I., Burtt, K., Solorzano, C., & Carey, J. (2016). Innovations in surgery simulation: A review of past, current and future techniques. *Annals of Translational Medicine*, *4*(23), 453.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *34*(2), 191–215.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). Chapter 14: Self-efficacy: The exercise of control. New York: W.H. Freeman and Company.

Badura, A. (2006). Guide for constructing self-efficacy scales. In Pajares, F. & Urdan, T. (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307–337). Connecticut: Information Age Publishing.

Banasick, S. (2016). Ken-Q Analysis© (Version 1.0.1).[Computer software]. Available from https://shawnbanasick.github.io/ken-q-analysis/

Bantz, D., Dancer, M., Hodson-Carton, K., van Hove, S. (2007). A daylong clinical laboratory: From gaming to high-fidelity simulators. *Nurse Educator*, *32*(6), 274–277.

Barbosa, J., Willoughby, P., Rosenberg, C., & Mrtek, R. (1998). Statistical methodology: VII. Q-methodology, a structural analytic approach to medical subjectivity. *Academic Emergency Medicine*, *5*(10), 1032–1040.

Barnett-Page, E. & Thomas, J. (2009). Methods for the synthesis of qualitative research: A critical review. *BMC Medical Research Methodology*, *11*(9), 3–25.

Barrows, H. (1993). An overview of the uses of standardized patients for teaching and evaluating clinical skills. *Academic Medicine*, *68*(6), 443–451.

Barsuk, J., McGaghie, W., Cohen, E., O'Leary, K., & Wayne, D. (2009). Simulation-based mastery learning reduces complications during central venous catheter insertion in a medical intensive care unit. *Critical Care Medicine*, *37*(10), 2697–2701.

Barsuk, J., Cohen, E., Williams, M., Scher, J., Jones, S., Feinglass, J., McGaghie, W., O'Hara, K., & Wayne, D. (2017). Simulation-based mastery learning for

thoracocentesis skills improves patient outcomes: A randomized trial. *Academic Medicine*, *93*(5), 729–735.

Basheti, I. (2014). The effect of using simulation for training pharmacy students on correct device technique. *American Journal of Pharmaceutical Education*, *78*(10), 1–10.

Batalden, P., Leach, D., Swing, S., Dreyfus, H., & Dreyfus, S. (2002). General competencies and accreditation in graduate medical education: An antidote to overspecification in the education of medical specialists. *Health Affairs*, *21*(5), 103–111.

Baxter, P. & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544–559.

Baxter, P., Akhtar-Dandesh, N., Valaitis, R., Stanyon, W., & Sproul, S. (2009). Simulated experiences: Nursing students share their perspectives. *Nurse Education Today*, *29*, 859–866.

Beaubien, J. & Baker, D. (2004). The use of simulation for training teamwork skills in health care: how low can you go? *Quality Safety Health Care*, *13*, 51–56.

Beck, J., & Mostow, J. (2008). How who should practice: Using learning decomposition to evaluate the efficacy of different types of practice for different types of students. In Woolf, B., Aimeur, E., Nkambou, R., & Lajoie, S. (eds.) *Intelligent Tutoring Systems*, ITS 2008. Lecture Notes in Computer Science, vol 5091. Springer, Berlin, Heidelberg, 353–362.

Beckham, N. (2013). Objective structured clinical evaluation effectiveness in clinical evaluation for family nurse practitioner students. *Clinical simulation in nursing*, *9*, 453–459.

Bengtsson, M. (2016). How to plan a perform a qualitative study using content analysis. *NursingPlus Open*, *2*, 8–14.

Benner, P. (2004). Using the Dreyfus model of skill acquisition to describe and interpret skill acquisition and clinical judgment in nursing practice and education. *Bulletin of Science, Technology & Society*, *24*(3), 188–199.

Berelson, B. (1952). *Content analysis in communication research*. New York: Hafner Publishing Company.

Berkhout, J., Teunissen, P., Helmich, E., van Exel, J., van der Vleuten, C., & Jaarsma, D. (2017). Patterns in clinical students' self-regulated learning behavior: a Q-methodology study. *Advances in Health Sciences Education*, *22*, 105–121.

Bishop, J. & Verleger, M. (2013). The flipped classroom: A survey of the research. 120th ASEE Annual Conference and Exposition, Paper ID #6219.

Bjerrum, A., Eika, B., Charles, P., & Hilberg, O. (2016). Distributed practice. The more the merrier? A randomized bronchoscopy simulation study. *Medical Education Online*, *21*, 30517.

Blanch-Hartigan, D. (2011). Medical students' self-assessment of performance: Results from three meta-analyses. *Patient Education and Counseling*, *84*(1), 3–9.

Block, S. (1994). A medical education Q-sort: Applications in medical education research. *Academic Medicine*, *69*(5), 343–345.

Blum, R., Raemer, D., Carroll, J., Sunder, N., Felstein, D., & Cooper, J. (2004). Crisis resource management training for anesthesia faculty: A new approach to continuing faculty education. *Medical Education*, *38*, 45–55.

Bokken, L., Rethans, J., Jöbsis, Q., Duvivier, R., Scherpbier, A., & van der Vleuten, C. (2010). Instructiveness of real patients and simulated patients in undergraduate medical education: A randomized experiment. *Academic Medicine*, *85*, 148–154.

Bond, W., Lammers, R., Spillane, L., Smith-Coggins, R., Fernandez, R., Reznek, M., Vozenilek, J., & Gordon, J. (2007). The use of simulation in emergency medicine: A research agenda. *Academic Emergency Medicine*, *14*, 353–364.

Botma, Y. (2014). Nursing student's perceptions on how immersive simulation promotes theory-practice integration. *International Journal of Africa Nursing Sciences*, *1*, 1–5.

Bradley, P. (2006). The history of simulation in medical education and possible future directions. *Medical Education*, *40*, 254–262.

Brand, H. & Schoonheim-Klein, M. (2009). Is the OSCE more stressful? Examination anxiety and its consequences in different assessment methods in dental education. European *Journal of Dental Education*, *13*, 147–153.

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). How people learn: Brain, mind, experience, and school (expanded edition). Washington, DC: National Academy Press.

Brauer, D. & Ferguson, K. (2014). The integrated curriculum in medical education: AMEE Guide No. 96. *Medical Teacher*, *37*, 312–322.

Brokaw, J., Mandzuk, C., Wade, M., Deal, D., Johnson, M., White, G., Wilson, J., & Zollinger, T. (2009). The influence of regional basic science campuses on medical students' choice of specialty and practice location: A historical cohort study. *BMC Medical Education*, *9*(29), 1–12.

Brown, S. (1980). *Political subjectivity – Applications of Q-methodology in political science*. New Haven, CT: Yale University Press.

Brown, S. (1996). Q methodology and qualitative research. *Qualitative Health Research*, *6*(4), 561–567.

Bullerjahn, C. & Güldenring, M. (1994). An empirical investigation of effects of film music using qualitative content analysis. *Psychomusicology*, *13*, 99–118.

Burgess, A., McGregor, D., & Mellis, C. (2014). Team-based learning programs in medical schools: A systematic review. *Academic Medicine*, *89*(4), 678–688.

Burke, H. & Mancuso, L. (2012). Social cognitive theory, metacognition, and simulation learning in nursing education. *Journal of Nursing Education*, *51*(10), 543–548.

Burns, K., Duffett, M., Kho, M, Meade, M., Adhikari, N., Sinuff, T., Cook, D. (2008). A guide for the design and conduct of self-administered surveys of clinicians. *Canadian Medical Association Journal*, *179*(3), 245–252.

Burton, L. & Mazerolle, S. (2011). Survey instrument validity part I: Principles of survey instrument development and validation in athletic training education research. *Athletic Training Education Journal*, *6*(1), 27–35.

Byrne, E. & Smyth, S. (2008). Lecturers' experiences and perspectives of using an objective structured clinical examination. *Nurse Education in Practice*, *8*, 283–289.

Calhoun, J., Ten Haken, J, & Woolliscroft, J. (1990). Medical students' development of self- and peer-assessment skills: A longitudinal study. *Teaching and Learning in Medicine*, *2*(1), 25–29.

Carraccio, C. & Englander, R. (2000). The Objective Structured Clinical Examination: A step in the direction of competency-based evaluation. *Archives of Pediatrics and Adolescent Medicine*, *154*, 736–741.

Carraccio, C., Benson, B., Nixon, J., & Derstine, P. (2008). From the educational bench to the clinical bedside: Translating the Dreyfus developmental model to the learning of clinical skills. *Academic Medicine*, *83*(8), 761–767.

Cazzell, M. & Howe, C. (2012). Using Objective Structured Clinical Evaluation for simulation evaluation: Checklist considerations for interrater reliability. *Clinical Simulation in Nursing*, *8*, 219–225.

Cendan, J. & Johnson, T. (2011). Enhancing learning through optimal sequencing of web-based and manikin simulators to teach shock physiology in the medical curriculum. *Advances in Physiology Education*, *35*, 402–407.

Cerino, V. (2016, July 27). UNMC receives grant for mobile simulation initiative. Retrieved from https://www.unmc.edu/news.cfm?match=18992

Charmaz, K. (2014). Constructing grounded theory. London: SAGE Publications Ltd.

Châtenay, M., Maguire, T., Skakun, E., Change, G., Cook, D., & Warnock, G. (1996). Does volume of clinical experience affect performance of clinical clerks on surgery exit examinations? *The American Journal of Surgery*, *172*, 366–372.

Chen, H. & Teherani, A. (2016). Common qualitative methodologies and research designs in health professions education. *Academic Medicine*, *91*(12), e5.

Chen, H., Kelly, M., Hayes, C., van Reyk, D., & Herok, G. (2016). The use of simulation as a novel experiential learning module in undergraduate science pathophysiology education. *Advances in Physiology Education*, *40*, 335–341.

Chen, F., Lui, A., & Martinelli, S. (2017). A systematic review of the effectiveness of flipped classrooms in medical education. *Medical Education*, *51*, 585–597.

Chinnis, A., Paulson, D., & Davis, S. (2001). Using Q methodology to assess the needs of emergency medicine support staff employees. *The Journal of Emergency Medicine*, *20*(2), 197–203.

Chipchase, L., Johnston, V., & Long, P. (2012). Continuing professional development: The missing link. *Manual Therapy*, *17*, 89–91.

Chopra, V., Gesink, B., de Jong, J., Bovill, J., Spierdijk, J., & Brand, R. (1994). Does training on an anaesthesia simulator lead to improvement in performance? *British Journal of Anaesthesia*, *73*, 293–297.

Cleland, J. (2017). The qualitative orientation in medical education research. *Korean Journal of Medical Education*, *29*(2), 61–71.

Clinton, J. (2004). Proxy variable. In Lewis-Black, M., Bryman, A., Liao, T. (Eds). *The SAGE Encyclopedia of Social Science Research Methods* (p. 878). Thousand Oaks: SAGE Publications Ltd.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159.

Cohen, A. & Cohen, R. (1990). Development of competence in clerkship. *Medical Teacher*, *12*(1), 47–56.

Colletti, L. (2000). Difficulty with negative feedback: Face-to-face evaluation of junior medical student clinical performance results in grade inflation. *Journal of Surgical Research*, *90*, 82–87.

Collins, J. & Harden, M. (1998). AMEE Medical Education Guide No. 13: Real patients, simulated patients and simulators in clinical examination. *Medical Teacher*, *20*(6), 508–521.

Coogan, J. & Herrington, N. (2011). Q methodology: An overview. *Research in Secondary Teacher Education*, *1*(2), 24–28.

Coombs, C., Shields, R., Hunt, E., Lum, Y., Sosnay, P., Perretta, J., Lieberman, R., & Shilkofski, N. (2017). Design, implementation, and evaluation of a simulation-based clinical correlation curriculum as an adjunctive pedagogy in an anatomy course. *Academic Medicine*, *92*(4), 494–500.

Cooper, J. & Taqueti, V. (2004). A brief history of the development of mannequin simulators for clinical education and training. *Quality Safety Health Care*, *13*(1), 11–18.

Cordovani, L. & Cordovani, D. (2016). A literature review on observational learning for medical motor skills and anesthesia teaching. *Advances in Health Science Education*, *21*(5), 1113–1121.

Correll, N., Wing, R., & Coleman, D. (2013). A one-year introductory robotics curriculum for computer science upperclassman. *IEEE Transactions in Education*, *56*(1), 54–60

Cosman, P., Hugh, T., Shearer, C., Merrett, N., Biankin, A., & Cartmill, J. (2007). Skills acquired on virtual reality laparoscopic simulators transfer into the operating room in a blinded, randomized, controlled trial. *Medicine Meets Virtual Reality*, *15*, 76–81.

Cross, R. (2005). Exploring attitudes: The case for Q methodology. He*alth Education Research*, *20*(2), 206–213.

Cross, E., Kraemer, D., Hamilton, A., Kelley, W., & Grafton, S. (2009). Sensitivity of the action observation network to physical and observational learning. *Cerebral Cortex*, *19*, 315–326.

Daley, B., Beman, S., Morgan, S., Kennedy, L., & Sheriff, M. (2017). Concepts maps: A tool to prepare for high fidelity simulation in nursing. *Journal of the Scholarship of Teaching and Learning*, *17*(4), 17–30.

Daniels, V. & Kassam, N. (2013). Impact of personal goals on the internal medicine R4 subspecialty match: A Q-methodology study. *BMC Medical Education*, *13*, 171.

Davidovitch, N. (2013). Learning-centered teaching and backward course design – From transferring knowledge to teaching skills. *Journal of International Education Research*, *9*(4), 329–338.

Davies, D., Mazmaniam, P., Fordis, M., Harrison, R., Thorpe, K., & Perrier, L. (2006). Accuracy of physician self-assessment compared with observed measures of competence: A systematic review. *Journal of the American Medical Association*, *296*, 1094–1102.

Dawson, S., Cotin, S., Meglan, D., Shaffer, D. & Ferrell, M. (2000). Designing a computer-based simulator for interventional cardiology training. *Catheterization and Cardiovascular Interventions*, *51*, 522–527.

Deakin, H. & Wakefield, K. (2014). Skype interviewing: Reflections of two PhD researchers. *Qualitative Research*, *14*(5), 603–616.

Decker, S., Fey, M., Sideras, S., Caballero, S., Rockstraw, L., Boese, T., Franklin, A., Gloe, D., Lioce, L., Sando, C., Meakim, C., & Borum, J. (2013). Standards of best

practice: Simulation standard VI: The debriefing process. *Clinical Simulation in Nursing*, *9*, 26–29.

Dennis, K. (1986). Q methodology: Relevance and application to nursing research. *Advances in Nursing Science*, *8*(3), 6–17.

Dennis, K. (1992). Looking at reliability and validity through Q-colored glasses. *Operant Subjectivity*, *16*(1), 37–44.

Deutsch, E. (2008). High-fidelity patient simulation mannequins to facilitate aerodigestive endoscopy training. *Archives of Otolaryngology–Head & Neck Surgery*, *134*(6), 625–629.

Devitt, J., Kurrek, M., Cohen, M., & Cleave-Hogg, D. (2001). The validity of performance assessments using simulation. *Anesthesiology*, *95*, 36–42.

DiCicco-Bloom, B. & Crabtree, B. (2006). The qualitative research interview. *Medical Education*, *40*, 314–321.

Dieckmann, P., Lippert, A., Glavin, R., & Rall, M. (2010). When things do not go as expected: Scenario life savers. *Simulation in Healthcare*, *5*, 219–225.

Dillman, D., Smyth, J., & Christian, L. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method. New Jersey: Wiley.

DiLullo, C. (2015). Learners of a new generation. In Chan, L. & Pawlina, W. (Eds.), *Teaching anatomy: A practical guide* (pp. 11–21). New York: Springer.

Dispenza, F., Harper, L., & Harrigan, M. (2016). Subjective health among LGBT persons living with disabilities: A qualitative content analysis. *Rehabilitation Psychology*, *61*(3), 251–259.

Domuracki, K., Moule, C., Owen, H., Kostandoff, G., & Plummer, J. (2009). Learning on a simulator does transfer to clinical practice. *Resuscitation*, *80*, 346–349.

Dori, Y., Hult, E., Breslow, L., & Belcher, J. (2007). How much have they retained? Making unseen concpets seen in a freshman electromagnetism course at MIT. *Journal of Science Education and Technology*, *16*(4), 299–323.

Dornan, T., Boshuizen, H., King, N., & Scherpbier, A. (2007). Experience-based learning: A model linking the processes and outcomes of medical students' workplace learning. *Medical Education*, *41*, 84–91.

Dornan, T., Scherpbier, A., & Boshuizen, H. (2009). Supporting medical students' workplace learning: Experience-based learning (ExBL). *The Clinical Teacher*, *6*, 167–171.

Dörnyei, Z., MacIntyre, P., Henry, A., & Al-Hoorie, A. (Eds.). (2015). Motivational dynamics in language learning. In *Series: Second Language Acquisition*. Bristol, England: Multilingual Matters.

Dotger, B., Dotger, S., & Maher, M. (2010). From medicine to teaching: The evolution of the simulated interaction model. *Innovative Higher Education*, *35*, 129–141.

Drake, R. (1998). Anatomy education in a changing medical curriculum. *The Anatomical Record*, *253*, 28–31.

Drake, R. (2014). A retrospective and prospective look at medical education in the United States: trends shaping anatomical sciences education. *Journal of Anatomy*, *224*, 256–260.

Dreifuerst, K. & Decker, S. (2012). Debriefing: An essential component for learning in simulation pedagogy, In Jeffries, P. (Ed). *Simulation in Nursing Education: From*

conceptualization to Evaluation (2nd ed) (pp. 105–129). Stevangen: Laerdal Medical Corporation.

Dreyfus, S. & Dreyfus, H. (1980). A five-stage model of the mental activities involved in directed skill acquisition. California University Berkeley Operations Research Center, 1–22.

Driskell, J. & Salas, E. (1996). Stress and human performance. New Jersey: Lawrence Erlbaum Associates.

Ehrlinger, J., Johnson, K., Banner, M., Dunning, D., & Kruger, J. (2008). Why the unskilled are unaware: Further explorations of (absent) self-insight among the incompetent. *Organizational Behavior and Human Decision Processes*, *105*(1), 98–121.

Eisenstein, A., Vaisman, L., Johnston-Cox, H., Gallan, A., Shaffer, K., Vaughan, D., O'Hara, C., & Joseph, L. (2014). Integration of basic science and clinical medicine: The innovative approach of the cadaver biopsy project at the Boston University School of Medicine. *Academic Medicine*, *89*, 1–4.

Elizabeth, J. & Hughes, S. (1986). An assessment of the preregistration year experience. *British Medical Journal*, *293*, 1559.

Elo, S. & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115.

Epstein, R. (2007). Assessment in medical education. *New England Journal of Medicine*, *356*, 387–396.

Eraut, M. (1994). Developing professional knowledge and competence. London: The Falmer Press.

Ericsson, A., Krampe, R., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363–406.

Ericsson, A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine*, *79*(10), 70–81.

Fanning, R. & Gaba, D. (2007). The role of debriefing in simulation-based learning. *Simulation in Healthcare*, *2*(2), 115–125.

Feather, R., Carr, D., Reising, D., & Garletts, D. (2016). Team-based learning for nursing and medical students: Focus group results from an interprofessional education project. *Nurse Educator*, *41*(4), 1–5.

Feingold, C., Calaluce, M., & Kallen, M. (2004). Computerized patient model and simulated clinical experiences: Evaluation with baccalaureate nursing students. *Journal of Nursing Education*, *43*(4), 156–163.

Ferguson, K. & Kreiter, C. (2004). Using a longitudinal database to assess the validity of preceptors' ratings of clerkship performance. *Advances in Health Sciences Education*, *9*, 39–46.

Fero, L., O'Donnell, J., Zullo, T., Dabbs, A., Kitutu, J., Samosky J., & Hoffman, L. (2010). Critical thinking skills in nursing students: comparison of simulation-based performance with metrics. *Journal of Advanced Nursing*, *66*(10), 2182–93.

Field, A. (2013). *Discovering statistics using IBM SPSS Statistics*. London: SAGE Publications Ltd.

Fincher, R. & Lewis, L. (1994). Learning, experience, and self-assessment of competence of third-year medical students in performing bedside procedures. *Academic Medicine*, *69*(4), 291–295.

Finnerty, E., Chauvin, S., Bonaminio, G., Andrews, M., Carroll, R., & Pangaro, L. (2010). Flexner revisited: The role and value of the basic sciences in medical education. *Academic Medicine*, *85*(2), 349–355.

Flexner, A. (1910). Medical education in the United States and Canada: A report to the Carnegie Foundation for the advancement of teaching, Bulletin No. 4. Boston: D.B. Updike, The Merrymount Press.

Flick, U. (2009). *An introduction to qualitative research*, 4th ed. London: SAGE Publications, Ltd.

Fokkema, J., Scheele, F., Westerman, M., van Exel, J., Scherpbier, A., van der Vleuten, C., Dörr, P., & Teunissen, P. (2014). Perceived effects of innovations in postgraduate medical education: A Q study focusing on workplace-based assessment. *Academic Medicine*, *89*, 1259–1266.

Frank, J., Snell, L., Ten Cate, O., Holmboe, E., Carraccio, C., Swing, S., Harris, P., Glasgow, N., Campbell, C., Dath, D. Harden, R., Iobst, W., Long, D., Mungroo, R., Richardson, D., Sherbino, J., Silver, I., Taber, S., Talbot, M., & Harris, K. (2010). Competency-based medical education: Theory to practice. *Medical Teacher*, *32*, 638–645.

Fried, G., Feldman, L., Vassiliou, M., Fraser, S., Stanbridge, D., Ghitulescu, G., & Andrew, C. (2004). Proving the value of simulation in laparoscopic surgery. *Annals of Surgery*, *240*, 518–528.

Fritz, P., Gray, T., & Flanagan, B. (2008). Review of mannequin-based high-fidelity simulation in emergency medicine. *Emergency Medicine Australasia*, *20*, 1–9.

Fry, M., MacGregor, C., Hyland, S., Payne, B., & Chenoweth, L. (2015). Emergency nurses' perceptions of the role of confidence, self-efficacy and reflexivity in managing the cognitively impaired older person in pain. *Journal of Clinical Nursing*, *24*, 1622–1629.

Gaba, D. & DeAnda, A. (1988). A comprehensive anesthesia simulation environment: Re-creating the operating room for research and training. *Anesthesiology*, *69*, 387–394.

Gaba, D. (1992). Improving anesthesiologists' performance by simulating reality. *Anesthesiology*, *76*, 491–494.

Gaebler-Uhing, C. (2003). Q-methodology: A systematic approach to assessing learners in palliative care education. *Journal of Palliative Medicine*, *6*(3), 438–442.

Galey, W. (1998). What is the future of problem-based learning in medical education? *Advances in Physiology Education*, *20*(1), 12–15.

Gantt, L. (2012). Who's driving? The role and training of the human patient simulation operator. *Computers, Informatics, Nursing*, *30*(11), 579–586.

Garbarini, F. & Adenzato, M. (2004). At the root of embodied cognition: Cognitive science meets neurophysiology. *Brain and Cognition*, *56*, 100–106.

George, D. & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference. 11.0 update (4th ed.). Boston, MA: Allyn & Bacon

Goldenberg, D., Andrusyszyn, M., & Iwasiw, C. (2005). The effect of classroom simulation on nursing students' self-efficacy related to health teaching. *Journal of*

Nursing Education, *44*(7), 310–314.

Gordon, J., Wilkerson, W., Shaffer, D., & Armstrong, E. (2001). "Practicing" medicine without risk: Students' and educators' responses to high-fidelity patient simulation. *Academic Medicine*, *76*(5), 469–472.

Gordon, M., Ewy, G., Felner, J., Forker, A., Gessner, I., McGuire, C., Mayer, J., Patterson, D., Sajid, A., & Waugh, R. (1980). Teaching bedside cardiologic examination skills using "Harvey", the cardiology patient simulator. *The Medical Clinics of North America*, *64*(2), 305–313.

Gorman, L., Castiglioni, A., Hernandez, C., Asmar, A., Cendan, J., & Harris, D. (2015). Using preclinical high-fidelity medical simulations to integrate pharmacology and physiology with clinical sciences. *Medical Science Educator*, *25*, 521–532.

Gormley, G. (2011). Summative OSCEs in undergraduate medical education. *Ulster Medical Journal*, *80*(3), 127-132.

Gormley, G., Sterling, M., Menary, A., & McKeown, G. (2012). Keeping it real! Enhancing realism in standardised patient OSCE stations. *The Clinical Teacher*, *9*, 382–386.

Gorrindo, T., Chevalier, L., Goldfarb, E., Hoeppner, B., & Birnbaum, R. (2014). Autonomic arousal and learning in web-based simulation: A feasibility study. *Journal of Continuing Education in the Health Professions*, *34*(1), 17–22.

Grande, T. (2014, June 10) Linear Regression in SPSS [video file]. Retrieved from https://www.youtube.com/watch?v=U2p16pCHW3c&t=227s

Graneheim, U. & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today*, *24*, 105–112.

Grantcharov, T., Kristiansen V., Bardram, B., Rosenberg, J., & Funch-Jensen, P. (2004). Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *British Journal of Surgery Society*, *91*, 146–150.

Grbich, C. (2013). *Qualitative data analysis: An introduction*, 2nd ed. London: SAGE Publications, Ltd.

Green, M., Aagaard, E., Caverzagie, K., Chick, D., Holmboe, E., Kane, G., Smith, C., & Iobst, W. (2009). Charting the road to competence: Developmental milestones for internal medicine residency training. *Journal of Graduate Medical Education*, *1*(1), 5–20.

Grice, G., Wenger, P., Brooks, N., & Berry, T. (2013). Comparison of patient simulation methods used in a physical assessment course. *American Journal of Pharmaceutical Education*, *77*(4), 1–5.

Groves, R. (2006). Nonresponse rates and nonresponse bias in household surveys. *The Public Opinion Quarterly*, *70*(5), 646–675.

Groves, R. & Peytcheva, E. (2008). The impact of nonresponse rates on nonresponse bias: A meta-analysis. *The Public Opinion Quarterly*, *72*(2), 167–189.

Guttman, L. (1954). Some necessary conditions for common-factor analysis. *Psychometrika*, *19*(2), 149–161.

Ha, E. (2014). Attitudes toward video-assisted debriefing after simulation in undergraduate nursing students: An application of Q methodology. *Nurse Education Today*, *34*, 978–984.

Ha, E. (2016). Undergraduate nursing students' subjective attitudes to curriculum for

Simulation-based objective structured clinical examination. *Nurse Education Today*, *36*, 11–17.

Haji, F., Hoppe, D., Morin, M., Giannoulakis, K., Koh, J., Rojas, D., & Cheung, J. (2014). What we call what we do affects how we do it: a new nomenclature for simulation research in medical education. *Advances in Health Sciences Education*, *19*, 273–280.

Hall, M., Sheakley, M., Callender, D., Pederson, D., Gilbert, G., & Leighton, K. (2016). Enhancing knowledge retention of cardiovascular physiology using simulation. *Medical Science Educator, 26*, 111–116.

Hall, S., Stephens, J., Seaby, E., Andrade, M., Lowry, A., Parton, W., Smith, C., & Border, S. (2016). Can medical students accurately predict their learning? A study comparing perceived and actual performance in neuroanatomy. *Anatomical Sciences Education*, *9*, 488–495.

Harden, R., Stevenson, M., Downie, W., & Wilson, G. (1975). Assessment of clinical competence using Objective Structured Examination. *British Medical Journal*, *22*, 447–451.

Härgestam, M., Lindkvist, M., Brulin, C., Jacobsson, M., & Hultin, M. (2013). Communication in interdisciplinary teams: Exploring closed-loop communication during in situ trauma team training. *BMJ Open*, *3*:e003525.

Harrell, P., Kearl, G., Reed, E., Grigsby, D., & Caudill, T. (1993). Medical students' confidence and the characteristics of their clinical experiences in a primary care clerkship. *Academic Medicine*, *68*, 577–579.

Harris, D., Bellew, C., Cheng, Z., Cendan, J., & Kibble, J. (2014). High-fidelity patient simulators to expose undergraduate students to the clinical relevance of physiology concepts. *Advances in Physiology Education*, *38*, 372–375.

Harris, D. (2016). Simulation for undergraduates: Is there a worthy return on investment? *Advances in Physiology Education*, *40*, 472.

Harvey, A., Nathens, A., Bandiera, G., & LeBlanc, V. (2010). Threat and challenge: Cognitive appraisal and stress responses in simulated trauma resuscitations. *Medical Education*, *44*, 587–594.

Harvey, R., Gillan, C., & Edgar, S. (2013). High fidelity simulation training for the primary FRCA OSCE, UK. *European Journal of Anaesthesiology*, *30*(1), 229.

Hee, C. & Euna, P. (2016). Diversity of emotional intelligence among nursing and medical students. *Osong Public Health and Research Perspectives*, *7*(4), 261–265.

Helmreich, R. & Davies, J. (1997). Anaesthetic simulation and lessons to be learned from aviation. *Canadian Journal of Anaesthesia*, *44*, 907–912.

Henneman, E., Cunningham, H., Roche, J., & Curnin, M. (2007). Human patient simulation: Teaching students to provide safe care. *Nurse Educator*, *32*(5), 212–217.

Hensel, D. (2016, March). *Using a quantitative method to study subjectivity in undergraduate research*. Presented at the IUPUI Edward C. Moore Symposium on Excellence in Teaching, Indianapolis, IN.

Hertzog, M. (2008). Considerations in determining sample size for pilot studies. *Research in Nursing and Health*, *31*, 180–191.

Herrmann, G., Woermann, U., & Schlegel, C. (2015). Interprofessional education in anatomy: Learning together in medical and nursing training. *Anatomical Sciences Education*, *8*, 324–330.

Hill, G. (1982). Group versus individual performance: Are N+1 heads better than one? *Psychological Bulletin*, *91*(3), 517–539.

Hopper, J. (2012). Park your demographics at the end. Retrieved from https://verstaresearch.com/blog/park-your-demographics-at-the-end/

Hsieh, H. & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9), 1277–1288.

Hsieh, M., Cheng, W. & Chen, T. (2014). Objective structured clinical examination (OSCE) including critical simulation: Evaluation of medical student competence. *Tzu Chi Medical Journal*, *26*, 40–43.

Hsu, L., Chang, W., & Hsieh, S. (2015). The effects of scenario-based simulation course training on nurses' communication competence and self-efficacy: A randomized controlled trial. *Journal of Professional Nursing*, *31*(1), 37–49.

Huang, W. & Grigoryan, L. (2017). Student self-assessment versus preceptor assessment at the midpoint of a family medicine clerkship. *Family Medicine and Community Health*, *5*(1), 65–70.

Huffman J., McNeil G., Bismilla Z., Lai A. (2016) Essentials of scenario building for simulation-based education. In Grant V. & Cheng A. (Eds.), *Comprehensive Healthcare Simulation: Pediatrics. Comprehensive Healthcare Simulation* (pp.19–29). Cham: Springer.

Hunziker, S., Buhlmann, C., Tschan, F., Balestra, G., Legeret, C., Schumacher, C., Semmer, N., Hunziker, P., & Marsch, S. (2010). Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: A randomized controlled trial. *Critical Care Medicine*, *38*(4), 1–6.

Hutchinson, L. (1999). Evaluating and researching the effectiveness of educational interventions. *British Medical Journal*, *318*, 1267–1269.

The Indiana Initiative: Physicians for the 21st Century, Draft Final Report. September 13, 1996, Indiana University School of Medicine (IUSM).

Interprofessional Education Collaborative Expert Panel. (2011). Core competencies for interprofessional collaborative practice: Report of an Expert Panel. Washington, DC: Interprofessional Education Collaborative.

Irby D., Cooke M., O'Brien B. (2010). Calls for reform of medical education by the Carnegie Foundation for the Advancement of Teaching: 1910 and 2010. *Academic Medicine*, *85*, 220–227.

Irvine, A. (2011). Duration, dominance and depth in telephone and face-to-face interviews: A comparative exploration. *International Journal of Qualitative Methods*, *10*(3), 202–220.

Issenberg, S., McGaghie, W., Hart, I., Mayer, J., Felner, J., Petrusa, E., Waugh, R., Brown, D., Safford, R., Gessner, I., Gordon, D., & Ewy G. (1999). Simulation technology for health care professional skills training and assessment. *The Journal of the American Medical Association*, *282*(9), 861–866.

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

Issenberg, S., Chung, H., & Devine, L. (2011). Patient safety training simulations based on competency criteria of the Accreditation Council for Graduate Medical Education. *Mount Sinai Journal of Medicine*, *78*, 842–853.

Jamniczky, H., Cotton, D., Paget, M., Ramji, Q., Lenz, R., McLaughlin, K., Coderre, S., & Ma, I. (2017). Cognitive load imposed by ultrasound-facilitated teaching does not adversely affect gross anatomy learning outcomes. *Anatomical Sciences Education*, *10*, 144–151.

Jaye, P., Thomas, L., & Reedy, G. (2015). 'The Diamond': A structure for simulation debrief. *The Clinical Teacher*, *12*, 171–175.

Jiang, G., Chen, H., Wang, S., Zhou, Q., Li, X., Chen, K., & Sui, X. (2011). Learning curves and long-term outcome of simulation-based thoracentesis training for medical students. *BMC Medical Education*, *11*, 39.

Jolly, B., Jones, A., Dacre, J., Elzubeir, M., Kopelman, P., & Hitman, G. (1996). Relationships between students' clinical experiences in introductory clinical courses and their performances on an Objective Structured Clinical Examination (OSCE). *Academic Medicine*, *71*(8), 909–916.

Jones, F., Passos-Neto, C., & Braghiroli, O. (2015). Simulation in medical education: Brief history and methodology. *Principles and Practice of Clinical Research*, *2*(1), 56–63.

Jones, J., Hunt, S., Carlson, S., Seamon, J. (1997). Assessing bedside cardiologic examination skills using "Harvey," a cardiology patient simulator. *Academic Emergency Medicine*, *4*(10), 980–985.

Kaiser, H. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*(1), 141–151.

Kaiser, H. (1970). A second generation little jiffy. *Psychometrika*, *35*(4), 401–415.

Kameg, K., Howard, V., Clochesy, J., Mitchell, A., & Suresky, J. (2010). The impact of high fidelity human simulation on self-efficacy of communication skills. *Issues in Mental Health Nursing*, *31*, 315–323.

Karabulut-Ilgu, A., Cherrez, N., Jahren, C. (2017). A systematic review of research on the flipped learning method in engineering education. *British Journal of Educational Technology*, *49*(3), 398–411.

Kardong-Edgren, S., Lungstrom, N., & Bendel, R. (2009). VitalSim® versus SimMan®: A comparison of BSN student test scores, knowledge retention, and satisfaction. *Clinical Simulation in Nursing*, *5*, e105-e111.

Kaufman, D. & Bell, W. (1997). Teaching and assessing clinical skills using virtual reality. *Medicine Meets Virtual Reality*, *39*, 467–472.

Kaufman, D. & Mann, K. (2010). Teaching and learning in medical education: How theory can inform practice. In Swanwick, T. (Ed.), *Understanding Medical Education: Evidence, Theory and Practice*. West Sussex: Wiley-Blackwell.

Khan, K., Gaunt, K., Ramachandran, S., & Pushkar, P. (2013). The objective structured clinical examination (OSCE): AMEE guide no. 81. Part II: Organization & Administration. *Medical Teacher*, *35*(9), 1447–1463.

Kim, Y., Dykema, J., Stevenson, J., Black, P., & Moberg, D. (2018). Straightlining: Overview of measurement, comparison of indicators, and effects in mail-web mixed-mode surveys. *Social Science Computer Review*, Advance online publication.

Kirkman, T. (2013). High fidelity simulation effectiveness in nursing students' transfer of learning. *International Journal of Nursing Education Scholarship*, *10*(1), 1–6.

Kneebone,R., Kidd, J., Nestel, D., Barnet, A., Lo, B., King, R., Yang, G., & Brown, R. (2005). Blurring the boundaries: Scenario-based simulation in a clinical setting. *Medical Education*, *39*, 580–587.

Kochhar, K. (2017, July). Survey Design. Oral presentation at the Anatomy Education Research Institute (AERI), Bloomington, Indiana.

Kohn, L., Corrigan, J., & Donaldson, M. (Eds.). (1999). To err is human: Building a safer health system. Institute of Medicine National Academy Press, Washington, DC.

Kolb, A. & Kolb, D. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*(2), 193–212.

Kolb, D. (1984). Experiential learning: Experience as the sources of learning and development. New Jersey: Prentice-Hall.

Kolb, D., Boyatzis, R., & Mainemelis, C. (2000). Experiential learning theory: Previous research and new directions. In Sternberg, R. & Zhang, L. (Eds.), *Perspectives on cognitive, learning, and thinking styles*. New Jersey: Lawrence Erlbaum.

Krippendorf, K. (2004). *Content analysis: An introduction to its methodology*, 2nd ed. Thousand Oaks: SAGE Publications Ltd.

Kruger, J. & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121–1134.

Kuduvalli, P., Parker, C., Leuwer, M., & Guha, A. (2009). Retention and transferability of team resource management skills in anaesthetic emergencies: The long-term impact of a high-fidelity simulation-based course. *European Journal of Anaesthesiology*, *26*(1), 17–22.

Kunkler, K. (2006). The role of medical simulation: An overview. *The International Journal of Medical Robotics and Computer Assisted Surgery*, 2, 203–210.

Landeen, J., Pierazzo, J., Akhtar-Danesh, N., Baxter, P., van Eijk, S., & Evers, C. (2015). Exploring student and faculty perceptions of clinical simulation: A Q-sort study. *Journal of Nursing Education*, *54*(9), 485–491.

Lapkin, S., Levett-Jones, T., Bellchambers, H., & Fernandez, R. (2010). Effectiveness of patient simulation manikins in teaching clinical reasoning skills to undergraduate nursing students: A systematic review. *Clinical Simulation in Nursing*, *8*(16), 661–694.

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

Lasater, K., (2005). High-fidelity simulation and the development of clinical judgment: Students' experiences. *Journal of Nursing Education*, *46*(6), 269–276.

Lasater, K. (2007). Clinical judgment development: Using simulation to create an assessment rubric. *Journal of Nursing Education*, *46*(11), 496–503.

LCME. (2017). Liaison Committee on Medical Education. Functions and Structure of a Medical School: Standards for Accreditation of Medical Education Programs Leading to the M.D. Degree. Washington DC: Association of American Medical

Colleges and the American Medical Association. Retrieved from http://lcme.org/wp-content/uploads/filebase/standards/2018-19_Functions-and-Structure_2017-08-02.docx

LeCompte, M. & Preissle, J. (1993). Ethnography and qualitative design in educational research, 2nd ed. San Diego: Academic Press, Inc.

Lee, J., Lee, Y., Lee, S., & Bae, J. (2016). Effects of high-fidelity patient simulation led clinical reasoning course: Focused on nursing core competencies, problem solving, and academic self-efficacy. *Japan Journal of Nursing Science*, *13*, 20–28.

Lee, M., Nam, K., & Kim, H. (2017). Effects of simulation with problem-based learning program on metacognition, team efficacy, and learning attitude in nursing students. *Computers, Informatics, Nursing*, *35*(3), 145–151.

LeFlore, J., Anderson, M., Michael, J., Engle, W., & Anderson, J. (2007). Comparison of self-directed learning versus instructor-modeled learning during a simulated clinical experience. *Simulation in Healthcare*, *2*, 170–177.

Leigh, G. (2008). High-fidelity patient simulation and nursing students' self-efficacy: A review of the literature. *International Journal of Nursing Education Scholarship*, *5*(1), 1–17.

Levett-Jones, T., Lapkin S., Hoffman K., Arthur, C., & Roche, J. (2011). Examining the impact of high and medium fidelity simulation experiences on nursing students' knowledge acquisition. *Nurse Education in Practice*, *11*, 380–383.

Levett-Jones, T., Lapkin S. (2012). The effectiveness of debriefing in simulation-based learning for health professionals: A systematic review. *JBI Library of Systematic Reviews*, *10*(51), 3295–3337.

Liaison Committee on Medical Education (LCME). (2016, March). Function and structure of a medical school: Standards for accreditation of medical education programs leading to the MD degree. Retrieved from http://lcme.org/publications/

Liaw, S., Scherpbier, A., Rethans, J., & Klainin-Yobas, P. (2012). Assessment for simulation learning outcomes: A comparison of knowledge and self-reported confidence with observed clinical performance. *Nurse Education Today*, *32*, 35–39.

Liaw, S., Chan, S., Chen, F., Hooi, S., & Siau, C. (2014). Comparison of virtual patient simulation with mannequin-based simulation for improving clinical performance in assessing and managing clinical deterioration: Randomized controlled trial. *Journal of Medical Internet Research*, *16*(9), e214.

Liddell, M., Davidson, S., Taub, H., & Whitecross, L. (2002). Evaluation of procedural skills training in an undergraduate curriculum. *Medical Education*, *36*, 1035–1041.

Lindholm, E. & Cheatham, C. (1983). Autonomic activity and workload during learning of a simulated aircraft carrier landing task. *Aviation, Space, and Environmental Medicine*, *54*(5), 435–39.

Lucas, S., Tuncel, A., Bensalah, K., Zeltser, I., Jenkins, A., Pearle, M., & Cadeddu, J. (2008). Virtual reality training improves simulated laparoscopic surgery performance in laparoscopy naïve medical students. *Journal of Endourology*, *22*(5), 1047–1051.

Luctkar-Flude, M., Wilson-Keates, B., & Larocque, M. (2012). Evaluating high-fidelity human simulators and standardized patients in an undergraduate nursing health assessment course. *Nurse Education Today*, *32*, 448–452.

Mackay, S., Morgan, P., Datta, V., Chang, A., & Darzi, A. (2002). Practice distribution in procedural skills training. *Surgical Endoscopy*, *16*, 957–961.

Mamede, S., Schmidt, H., & Rikers, R. (2007). Diagnostic errors and reflective practice in medicine. *Journal of Evaluation in Clinical Practice*, *13*, 138–145.

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

Mårtenseson, G. & Löfmark, A. (2013). Implementation and student evaluation of clinical final examination in nursing education. *Nurse Education Today*, *33*, 1563–1568.

Marteau, T., Humphrey, C., Matoon, G., Kidd, J., Lloyd, M., & Horder, J. (1991). Factors influencing the communication skills of first-year clinical medical students. *Medical Education*, *25*, 127–134.

Mavis, B. (2001). Self-efficacy and OSCE performance among second year medical students. *Advances in Health Sciences Education*, *6*, 93–102.

Mayring, P. (2000). Qualitative content analysis. *Forum: Qualitative Social Research*, *1*(2), 1–10.

Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solutions*. Klagenfurt. Retrieved from http://nbn-resolving.de/urn:nbn:de:0168-ssoar-395173

MAXQDA (Version 12) [Computer software]. VERBI Software Consult. (2015). Sozialforschung GmbH. Berlin, Germany.

McBride, J. & Drake, R. (2015). Student perceptions of an interprofessional educational experience: The importance of goal articulation. *Anatomical Sciences Education*, *8*, 381–385.

McBride, J. & Drake, R. (2018). National Survey on Anatomical Sciences in Medical Education. *Anatomical Sciences Education*, *11*, 7–14.

McCaughan, D., Thompson, C., Cullum, N., Sheldon, T., & Thompson, D. (2002). Acute care nurses' perceptions of barriers to using research information in clinical decision-making. *Journal of Advanced Nursing*, *39*(1), 46–60.

McClimens, A., Ibbotson, R., Kenyon, C., McLean, S., Soltani, H. (2012). Confidence and performance in objective structured clinical examination. *British Journal of Midwifery*, *20*(10), 746–751.

McCoy, L., Pettit, R., Lewis, J., Allgood, A., Bay, C., & Schwartz, F. (2016). Evaluating medical student engagement during virtual patient simulations: A sequential, mixed methods study. *BMC Medical Education*, *16*, 20.

McGaghie, W., Siddall, V., Mazmanian, P., & Myers, J. (2009). Lessons for continuing medical education from simulation research in undergraduate and graduate medical education. *Chest*, *135*, 62–68.

McGaghie, W., Issenberg, S., Petrusa, E., & Scalese, R. (2010). A critical review of simulation-based medical education research: 2003-2009. *Medical Education*, *44*, 50–63.

McGaghie, W., Issenberg, S., Cohen, E., Barsuk, J., & Wayne, D. (2011). Does simulation-based medical education with deliberate practice yield better results

than traditional clinical education? A meta-analytic comparative review of the evidence. *Academic Medicine*, *86*(6), 706–711.

McKeown, B. & Thomas, D. (2013). *Q methodology*, 2nd ed. Los Angeles: SAGE Publications, Inc.

McManus, I., Richards, P., Winder, B., Sporston, K., & Vincent, C. (1993). The changing clinical experience of British medical students. *Lancet, 341*, 941–4.

McManus, I., Richards, P., Winder, B., & Sproston, K. (1998). Clinical experience, performance in final examinations, and learning style in medical students: Prospective study. *British Medical Journal, 316*, 345–350.

Meade, L., Caverzagie, K., Swing, S., Jones, R., O'Malley, C., Yamazaki, K., & Zaas, A. (2013). Playing with curricular milestones in the educational sandbox: Q-sort results from an internal medicine educational collaborative. *Academic Medicine, 88*(8), 1142–1148.

Mehta, N., Hull, A., Young, J., & Stoller, J. (2013). Just imagine: New paradigms for medical education. *Academic Medicine*, *88*(10), 1418–1423.

Merriam, S. (2009). *Qualitative research: A guide to design and implementation*. San Francisco: Jossey-Bass.

Messbarger, R. (2001). Waxing poetic: Anna Morandi Manzolini's anatomical sculptures. *Configurations*, *9*(1), 65–97.

Michaelsen, L. & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, *116*, 7–27.

Miller, T. & Geraci, L. (2013). Unskilled but aware: Reinterpreting overconfidence in low-performing students. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, Advance online publication.

Minter, R., Gruppen, L., Napolitano, K., & Gauger, P. (2005). Gender differences in the self-assessment of surgical residents. *The American Journal of Surgery*, *189*, 647–650.

Moazed, F., Cohen, E., Furiasse, N., Singer, B., Corbridge, T., McGaghie, W., & Wayne, D. (2013). Retention of critical care skills after simulation-based mastery learning. *Journal of Graduate Medical Education*, *5*(3), 458–463.

Mompoint-Williams, D., Brooks, A., Lee, L., Watts, P., & Moss J. (2014). Using high-fidelity simulation to prepare advanced practice nursing students. *Clinical Simulation in Nursing*, *10*, 5–10.

Moores, T. & Chang, J. (2009). Self-efficacy, overconfidence, and the negative effect on subsequent performance: A field study. *Information & Management*, *46*, 69–76.

Morgan, P. & Cleave-Hogg, D. (2002). Comparison between medical students' experience, confidence and competence. *Medical Education*, *36*, 534–539.

Morgan, P., Cleave-Hogg, D., Desousa, S., & Lam-McCulloch, J. (2016). Applying theory to practice in undergraduate education using high fidelity simulation. *Medical Teacher*, *28*(1), 10–15.

Morriss-Kay, G. (2008). Flesh and wax: The Clemente Susini's anatomical models in the University of Cagliari. *Journal of Anatomy*, *213*, 496–497.

Mowbray, C., Holter, M., Teague, G., & Bybee, D. (2003). Fidelity criteria: Development, measurement, and validation. *American Journal of Education*, *24*(3), 315–340.

Mukaka, M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical research. *Malawi Medical Journal*, *24*(3), 69–71.

Munshi, F., Lababidi, H., & Alyousef, S. (2015). Low- versus high-fidelity simulations in teaching and assessing clinical skills. *Journal of Taibah University Medical Sciences*, *10*(1), 12–15.

Nazzawi, A. (2017). Dental students' perception of the Objective Structured Clinical Examination (OSCE): The Taibah University experience, Almadinah Almunawwarah, KSA. *Journal of Taibah University Medical Sciences*, *13*(1), 64–69.

Nestel, D., Tabak, D., Tierney, T., Layat-Burn, C., Robb, A., Clark, S., Morrison, T., Jones, N., Ellis, R., Smith, C., McNaughton, N., Knickle, K., Higham, J., & Kneebone, R. (2011). Key challenges in simulated patient programs: An international comparative case study. *BMC Medical Education*, *11*:69.

Niekrash, C., Copes, L., & Gonzalez, R. (2015). Frank Netter's legacy: Interprofessional anatomy instruction. *Anatomical Sciences Education*, *8*, 348–359.

Nolan, J., Desale, S., Padmore, J., Weissinger, P., & Furlong, M. (2017). Correlating preclinical ambulatory care specialty exposure with first-year medical student performance on an objective structured clinical examination. *Medical Science Educator*, *27*, 657–662.

Nourbakhsh, N., Wang, Y., Chen, F., & Calvo, R. (2012). Using galvanic skin response for cognitive load measurement in arithmetic and reading tasks. Proceedings of the 24th Australian Computer-Human Interaction Conference. p. 420–423.

Nyssen, A., Larbuisson, R., Janssens, M., Pendeville, P., & Mayne, A. (2002). A Comparison of the Training Value of Two Types of Anesthesia Simulators: Computer Screen-Based and Mannequin-Based Simulators. *Anesthesia & Analgesia*, *94*, 1560–1565.

Official guide: book of the fair. (1933). Chicago: A Century of Progress.

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

O'Leary, K., Wobbrock, J., & Riskin, E. (2013). Q-methodology as a research and design tool for HCI. *CHI Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1941–1950.

Opie, C. (2004). Doing Educational Research. London: SAGE Publications Ltd.

O'Regan, N. & Coombs-Thorne, H. (2017). Physiologic storyboarding for scenario development in high-fidelity simulation. *Medical Science Educator*, *27*, 385–390.

Ormrod, J. (2012). Human learning, 6th ed. Boston: Pearson Education Inc.

Owen, H., Follows, V., Reynolds, K., Burgess, G., & Plummer, J. (2002). Learning to apply effective cricoid pressure using a part task trainer. *Anaesthesia*, *57*, 1098–1101.

Owen, H. (2016). *Simulation in healthcare education: An extensive history*. Switzerland: Springer International Publishing.

Paige, J. (2013). Simulation design characteristics: Perspectives held by nurse educators and nursing students (Doctoral dissertation). Retrieved from University of Wisconsin Milwaukee Digital Commons.

Paige, J. (2014). Making sense of methods and measurement: Q-methodology – Part I – Philosophical background. *Clinical Simulation in Nursing*, *10*, 639–640.

Paige, J. (2015). Making sense of methods and measurement: Q-methodology – Part II – Methodological procedures. *Clinical Simulation in Nursing*, *11*, 75–77.

Pajares, F., Hartley, J., & Valiante, G. (2001). Response format in writing self-efficacy assessment: Greater discrimination increases prediction. *Measurement and Evaluation in Counseling and Development*, *33*, 214–221.

Panek, P. & Harvey, S. (1984). Relationship between actual performance and perceived performance across the life span. Annual Convention of the American Psychological Association, Toronto, Canada, August 24–28.

Park, J. (2015). Proposal for a modified Dreyfus and Miller model with simplified competency level descriptions for performing self-rated surveys. *Journal of Educational Evaluation for Health Professions*, *12*:54.

Parnell, D. (1978). The case for competency-based education, Bloomington, IN: The Phi Delta Kappa Educational Foundation.

Patton, M. (1990). Qualitative evaluation and research methods, 2nd ed. Newbury Park, CA: SAGE Publications Ltd.

Peña, A. (2010). The Dreyfus model of clinical problem-solving skills acquisition: A critical perspective. *Medical Education*, *15*, 4846.

Pfaff, M. (2014). Interprofessional simulations: Student attitudes and effects on SBAR performance. *Nursing Theses and Capstone Projects*, Paper 32.

Pfeil, U. & Zaphiris, P. (2009). Applying qualitative content analysis to study online support communities. *Universal Access in the Information Society*, *9*(1), 1–16.

Phitayakorn, R., Minehart, R., Pian-Smith, M., Hemingway, M., & Petrusa, E. (2015). Practicality of using galvanic skin response to measure intraoperative physiologic autonomic activation in operating room team members. *Surgery*, *158*, 1415–1420.

Pierce, B. & Smith, S. (2001). The postdiction superiority effect in metacomprehension of text. *Memory and Cognition*, *29*(1), 62–67.

Pike, T. & O'Donnell, V. (2010). The impact of clinical simulation on learner self-efficacy in pre-registration nursing education. *Nurse Education Today*, *30*(5), 405–410.

Porter, S., Whitcomb, M., & Weitzer, W. (2004). Multiple surveys of students and survey fatigue. *New Directions for Institutional Research*, *121*, 63–73.

Prateepko, T. & Chongsuvivatwong, V. (2009). Patterns of perception toward influenza pandemic among the front-line responsible health personnel in southern Thailand: a Q methodology approach. *BMC Public Health*, *9*, 161.

Prion, S., Berman, A., Karshmer, J., Van, P., Wallace, J., & West, N. (2015). Preceptor and self-evaluation competencies among new RN graduates. *The Journal of Continuing Education in Nursing*, *46*(7), 303–308.

Prober, C. & Khan, S. (2013). Medical education reimagined: A call to action. *Academic Medicine*, *88*(10), 1407–1410.

Pruneddu, A. (2011). Q-sortware (Version 2) [Computer software]. York, England: University of York. Available from http://www.qsortware.net

Quraishi, S., Kimatian, S., Murray, W., Sinz, E. (2011). High-fidelity simulation as an experiential model for teaching root cause analysis. *Journal of Graduate Medical Education*, *3*(4), 529–534.

Reber, B., Kaufman, S., & Cropp, F. (2000). Assessing Q-assessor: A validation study of computer-based Q sorts versus paper sorts. *Operant Subjectivity*, *23*(4), 192–209.

Reeves, S., Zwarenstein, M., Goldman, J., Barr, H., Freeth, D., Hammick, M., & Koppel, I. (2008). Interprofessional education: Effects on professional practice and health care outcomes (Review). *Cochrane Database of Systematic Reviews*, *1*, 1–22.

Reeves, S., Perrier, L., Goldman, J., Freeth, D., & Zwarenstein, M. (2013). Interprofessional education: Effects on professional practice and healthcare outcomes (Update) (Review). *Cochrane Database of Systematic Reviews*, *3*, 1–49.

Regehr, G., Hodges, B., Tiberius, R., & Lofchy, J. (1996). Measuring self-assessment skills: An innovative relative ranking model. *Academic Medicine*, *71*(10), S52–S54.

Reilly, A. & Spratt, C. (2007). The perceptions of undergraduate nursing student nurses of high-fidelity simulation-based learning: A case report from the University of Tasmania. *Nurse Education Today*, *27*, 542–550.

Reinhardt, A., Mullins, I., De Blieck, D., & Schultz, P. (2012). IV insertion simulation: confidence, skill, and performance. *Clinical Simulation in Nursing*, *8*, 157–167.

Reising, D., Carr, D., Shea, R., & King, J. (2011). Comparison of communication outcomes in traditional versus simulation strategies in nursing and medical students. *Nursing Education Perspectives*, *32*(5), 323–327.

Reising, D., Carr, D., Tieman, S., Feather, R., and Ozdogan, Z. (2015). Psychometric testing of a simulation rubric for measuring interprofessional communication. *Nursing Education Perspectives*, *36*(5), 311–316.

Rentschler, D., Eaton, J., Cappiello, J., McNally, S., & McWilliam, P. (2007). Evaluation of undergraduate students using objective structured clinical evaluation. *Journal of Nursing Education*, *46*(3), 135–139.

Richardson, J. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review*, *6*, 135–147.

Roa, K. & Roa, R. (2009). Perspectives in medical education 8. Enhancing preclinical education in Japan with a clinically focused, interactive anatomy curriculum. *The Keio Journal of Medicine*, *58*(4), 210–215.

Roberts, S., Warda, M., Garbutt, S., & Curry, K. (2014). The use of high-fidelity simulation to teach cultural competence in the nursing curriculum. *Journal of Professional Nursing*, *30*(3), 259–265.

Rodgers, W., Markland, D., Selzler, A., Murray, T., & Wilson, P. (2014). Distinguishing perceived competence and self-efficacy: An example from exercise. *Research Quarterly for Exercise and Sport*, *85*, 527–539.

Roh, Y. (2014). Effects of high-fidelity patient simulation on nursing students' resuscitation-specific self-efficacy. *Computers, Informatics, Nursing*, *32*(2), 84–89.

Rosen, K. (2008). The history of medical simulation. *Journal of Critical Care*, *23*, 157–166.

Rosen, K., McBride, J., & Drake, R. (2009). The use of simulation in medical education to enhance students' understanding of basic sciences. *Medical Teacher*, *31*, 842–846.

Rourke, L., Schmidt, M., & Garga, N. (2010). Theory-based research of high fidelity simulation use in nursing education: A review of the literature. *International Journal of Nursing Education Scholarship*, *7*(1), 1–14.

Rowe, G., Wright, G., & Bolger, F. (1991). Delphi: A reevaluation of research and theory. *Technological forecasting and social change*, *39*, 235–251.

Royal, K. (2016a). A guide for assessing the interpretive validity of student evaluations of teaching in medical school. *Medical Science Educator*, *26*, 711–717.

Royal, K. (2016b). A guide for making valid interpretations of student evaluation of teaching (SET) results. *Journal of Veterinary Medical Education*, *44*(2), 316–322.

Royal, K. & Flammer, K. (2017). Survey incentives in medical education: What do students say will entice them to participate in surveys? *Medical Science Educator*, *27*, 339–344.

Salter, S., Vale, S., Sanfilippo, F., Loh, R., Clifford, R. (2014). Long-term effectiveness of online anaphylaxis education for pharmacists. *American Journal of Pharmaceutical Education*, *78*(7), 1–11.

Sawdon, M. & Finn, G. (2014). The 'unskilled and unaware' effect is linear in a real-world setting. *Journal of Anatomy*, *224*, 279–285.

Scalese, R., Obeso, V., & Issenberg, S. (2007). Simulation technology for skills training and competency assessment in medical education. *Journal of General Internal Medicine*, *23*(Suppl), 46–49.

Schmolck, P. & Atkinson, J. (2014). PQMethod software and manual version 2.11. Accessed December 17th, 2017. Available at: http://schmolck.userweb.mwn.de/qmethod/#PQMethod/

Schwartz-Barcott, D., Patterson, B., Lusardi, P., & Farmer, B. (2002). From practice to theory: Tightening the link via three fieldwork strategies. *Journal of Advanced Nursing*, *39*(3), 281–289.

Schwartz, S. & Griffin, T. (1993). Comparing different types of performance feedback and computer-based instruction in teaching medical students how to diagnose acute abdominal pain. *Academic Medicine*, *68*, 862–864.

Scott, S., Baker, R., Shucksmith, J., & Kaner, E. (2014). Autonomy, special offers and routines: A Q methodological study of industry-driven marketing influences on young people's drinking behavior. *Addiction*, *109*, 1833–1844.

Selim, A., Ramadan, F., El-Gueneidy, M., & Gaafer, M. (2012). Using Objective Structured Clinical Examination (OSCE) in undergraduate psychiatric nursing education: Is it reliable and valid? *Nurse Education Today*, *32*, 283–288.

Seropian, M., Brown, K., Gavilanes, J., & Driggers, B. (2003). An approach to simulation program development. *Journal of Nursing Education*, *43*(4), 170–174.

Sharma, M., Chandra, P., & Chaturvedi, S. (2013). Objective Structured Clinical Examination and its impact on clinical and interpersonal skills: Follow-up study. *Indian Journal of Psychological Medicine*, *35*(3), 299–301.

Sheakley, M., Gilbert, G., Leighton, K., Hall, M., Callender, D., & Pederson, D. (2016). A brief simulation intervention increasing basic science and clinical knowledge. *Medical Education Online*, *21*, 30744.

Shinnick, M., Woo, M., Horwich, T., & Steadman, R. (2010). Debriefing: The most important component in simulation? *Clinical Simulation in Nursing*, *7*, 105–111.

Sica, G., Barron, D., Blum, R., Frenna, T., & Raemer, D. (1999). Computerized realistic simulation: A teaching module for crisis management in radiology. American *Journal of Roentgenology*, *172*, 301–304.

Smallman, H. & St. John, M. (2005). Naïve realism: Misplaced faith in realistic displays. *Ergonomics in Design*, *13*(3), 6–13.

Span, P. (2015). Content analysis of applied learning from high fidelity patient simulation orientation to critical care. *CUNY Academic Works*.

Speechley, M., Weston, W., Dickie, G., & Orr, V. (1994). Self-assessed competence: Before and after residency. *Canadian Family Physician*, *40*, 459–464.

Sperl-Hillen, J., O'Connor, P., Ekstrom, H., Rush, W., Asche, S., Fernandes, O., Appana, D., Amundson, G., & Johnson, P. (2013). Using simulation technology to teach diabetes care management skills to resident physicians. *Journal of Diabetes Science and Technology*, *7*(5), 1243–1254.

Spurgin, K. & Wildemuth, B. (2016). Content analysis. In Wildemuth, B. (Ed.) *Applications of Social Research Methods to Questions in Information and Library Science* (2nd ed., pp. 307–317). Oxford: Pearson Education.

Steadman, R., Coates, W., Huang, Y., Matevosian, R., Larmon, B., McCullough, L., & Ariel, D. (2006). Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. *Critical Care Medicine*, *38*(1), 151–157.

Steinman, K. (2014). Commentary: Key issues to consider for reviewing and designing simulated patient studies. *International Journal of Epidemiology*, *43*, 903–905.

Stephenson, W. (1935). Correlating persons instead of tests. *Journal of Personality*, *4*(1), 17–24.

Stewart, J., O'Halloran, C., Barton, J., Singleton, S., Harrigan, P., & Spencer, J. (2000). Clarifying the concepts of confidence and competence to produce appropriate self-evaluation measurement scales. *Medical Education*, *34*, 903–909.

Stokes-Parish, J., Duvivier, R., & Jolly, B. (2017). Does appearance matter? Current issues and formulation of a research agenda for moulage in simulation. *Society for Simulation in Healthcare*, 12(1), 47–50.

Stroben, F., Schröder, T., Dannenberg, K., Thomas, A., Exadaktylos, A., & Hautz, W. (2016). A simulated night shift in the emergency room increases students' self-efficacy independent of role taking over during simulation. *BMC Medical Education*, *16*, 177.

Stuart, M., Goldstein, H., & Snope, F. (1980). Self-evaluation by residents in family medicine. *The Journal of Family Practice*, *10*(4), 639–642.

Sullivan, J. (2012). Skype: An appropriate method of data collection for qualitative interviews? *The Hilltop Review*, *6*(1), 54–60.

Sweet, L. (2002). Telephone interviewing: Is it compatible with interpretive phenomenological research? *Contemporary Nurse*, *12*(1), 58–63.

Takashina, T., Shimizu, M., & Katayama, H. (1997). *A new cardiology patient simulator. Cardiology*, *88*, 408–413.

Tavakol, M. & Sandars, J. (2014). Quantitative and qualitative methods in medical education research: AMEE guide no 90: Part II. *Medical Teacher*, *36*, 838–848.

ten Klooster, P., Visser, M., & de Jong, M. (2008). Comparing two image research instruments: The Q-sort method versus the Likert attitude questionnaire. *Food Quality and Preference*, *19*, 511–518.

Tips and Tools #18: Coding Qualitative Data. (n.d.). Retrieved from http://programeval.ucdavis.edu/analysis-reporting/documents/CodingQualitative Data.pdf

Torres, K., Torres, A., Pietrzyk, L. Lisiecka, J., Blonski, M., Bacik-Donica, M., Staskiewicz, G., & Maciejewski, R. (2014). Simulation techniques in the anatomy curriculum: Review of literature. *Folia Morphologica*, *73*(1), 1–6.

Turner, D. (2010). Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report*, *15*(3), 754–760.

Turner, J. & Dankoski, M. (2008). Objective structured clinical exams: A critical review. *Family Medicine*, *40*(8), 574–578.

Qualtrics [Computer software] (April-July, 2017). Qualtrics, LLC, Provo, UT. Copyright © 2017.

Vadnais, M., Dodge, L., Awtrey, C., Ricciotti, H., Golen, T., & Hacker, M. (2012). Assessment of long-term knowledge retention following single-day simulation training for uncommon but critical obstetrical events. *The Journal of Maternal-Fetal & Neonatal Medicine*, *25*(9), 1640–1645.

Valenta, A. & Wigger, U. (1997). Q-methodology: Definition and application in health care informatics. *Journal of the American Medical Informatics Association*, *4*(6), 501–510.

van Schaik, S., Plant, J., Diane, S., Tsang, L., & O'Sullivan, P. (2011). Interprofessional team training in pediatric resuscitation: A low-cost, in situ simulation program that enhances self-efficacy among participants. *Clinical Pediatrics*, *50*(9), 807–815.

Veloski, J., Boex, J., Grasberger, M., Evans, A., Wolfson, D. (2006). Systematic review of the literature on assessment, feedback and physicians' clinical performance: BEME Guide No. 7. *Medical Teacher*, *28*(2), 117–128.

Vyas, D., Wombwell, E., Russell, E., Caligiuri, F. (2010). High-fidelity patient simulation series to supplement introductory pharmacy practice experiences. *American Journal of Pharmaceutical Education*, *74*(9), 1–8.

Wallenburg, I., van Exel, J., Stolk, E., Scheele, F., de Bont, A., & Meurs, P. (2010). Betweeen trust and accountability: Different perspectives on the modernization of postgraduate medical training in the Netherlands. *Academic Medicine*, *85*(6), 1082–1090.

Walsh, C., Seldomridge, L., & Badros, K. (2008). Developing a practical evaluation tool for preceptor use. *Nurse Educator*, *33*(3), 113–117.

Walsh, C., Garg, A., Ng, S., Goyal, F., & Grover, S. (2017). Residents' perceptions of simulation as a clinical learning approach. *Canadian Medical Education Journal*, *8*(1), 76–87.

Watts, S. & Stenner, P. (2005). Doing Q methodology: Theory, method and interpretation. *Qualitative Research in Psychology*, *2*, 67–91.

Watts, S. & Stenner, P. (2012). *Doing Q methodological research: Theory, method and interpretation*. London: SAGE Publications Ltd.

Wayne, D., Butter, J., Siddall, V., Fudala, M., Wade, L., Feinglass, J., McGaghie, W. (2006). Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. *Journal of General Internal Medicine*, *21*, 251–256.

Weber, R. (1990). *Basic content analysis*. Newbury Park: SAGE Publications Ltd.

Webler, T., Danielson, S., & Tuler, S. (2009). Using Q method to reveal social perspectives in environmental research. Greenfield MA: Social and Environmental Research Institute. Retrieved from http://www.seri-us.org/sites/default/files/Qprimer.pdf

Weiler, D. & Saleem, J. (2017). Role assignment in high fidelity patient simulation and the effects on nursing students' self-efficacy development. *Proceeding of the Human Factors and Ergonomics Society 2017 Annual Meeting*, *61*(1), 671–675.

Weiner, D., Morone, N., Spallek, H., Karp, J., Schneider, M., Washburn, C., Dziabiak, M., Hennon, J., & Elnicki, D. (2014). E-learning module on chronic low back pain in older adults: Evidence of effect on medical student objective structured clinical examination performance. *Journal of the American Geriatrics Society*, *62*, 1161–1167.

Weis, P. & Guyton-Simmons, J. (1998). A computer simulation for teaching critical thinking skills. *Nurse Educator*, *23*(2), 30–33.

Weller, J. (2004). Simulation in undergraduate medical education: Bridging the gap between theory and practice. *Medical Education*, *38*, 32–38.

Weller, J., Nestel, D., Marshall, S., Brooks, P., & Conn, J. (2012). Simulation in clinical teaching and learning. *The Medical Journal of Australia*, *196*(9), 1–5.

Westberg, J. & Jason, H. (1994). Fostering learners' reflection and self-assessment. *Family Medicine*, *26*(5), 278–282.

White, A., Brannan, J., Long, J., & Kruszka, K. (2013). Comparison of instructional methods: Cognitive skills and confidence levels. *Clinical Simulation in Nursing*, *9*, 417–423.

Wiggins, G. & McTighe, J. (2005). Understanding by Design, 2nd ed. Alexandria: Association for Supervision and Curriculum Development.

Wilkes, M. & Bligh, J. (1999). Evaluating educational interventions. *British Medical Journal*, *318*, 1269–1272.

Williams, W. (2004). Blissfully incompetent. *Psychological Science in the Public Interest*, *5*(3), i–ii.

Wisborg, T., Brattebo, G., Brinchmann-Hansen, A., & Hansen, K. (2009). Mannequin or standardized patient: Participants' assessment of two training modalities in trauma team simulation. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *17*:59.

Wong, A., Gang, M., Szyld, D., & Mahoney, H. (2016). Making an "attitude adjustment": Using a simulation-enhanced interprofessional education strategy to improve attitudes toward teamwork and communication. *Simulation in Healthcare*, *11*, 117–125.

Woolliscroft, J., Ten Haken, J., Smith, J., & Calhoun, J. (1993). Medical students' clinical self-assessments: Comparisons with external measures of performance and the students' self-assessments of overall performance and effort. *Academic Medicine*, *68*(4), 285–294.

World Health Organization. (2010). Framework for action on interprofessional education and collaborative practice. Geneva, Switzerland.

Wright, S., Lindell, C., Hinckley, W., Williams, A., Holland, C., Lewis, C., & Heimburger, G. (2006). High fidelity medical simulation in the difficult environment of a helicopter: Feasibility, self-efficacy and cost. *BMC Medical Education*, *6*, 49.

Yang, H., Thompson, C., & Bland, M. (2012). The effect of clinical experience, judgment task difficulty and time pressure on nurses' confidence calibration in a high fidelity clinical simulation. *BMC Medical Informatics and Decision Making*, *12*(113), 1–9.

Yardley, S., Teunissen, P., & Dornan, T. (2012). Experiential learning: Transforming theory into practice. *Medical Teacher*, *34*, 161–164.

Yeun, E., Bang, H., Ryoo, E., & Ha, E. (2014). Attitudes toward simulation-based learning in nursing students: An application of Q methodology. *Nurse Education Today*, *34*, 1062–1068.

Zach, K., Maloney, L., Praslick, A., Wackett, A., & Seidman, P. (2016). Medical student personal protective equipment training through simulated contamination. *Medical Science Educator*, *26*, 517–518.

Zafar, M. (2016). Medical students' perceptions of the effectiveness of integrated clinical skills sessions using different simulation adjuncts. *Advances in Physiology Education*, *40*, 514–521.

Zayyan, M. (2011). Objective structured clinical examination: The assessment of choice. *Oman Medical Journal*, *26*(4), 219–222.

Zhang, Y. & Wildemuth, B. (2016). Qualitative analysis of content. In Wildemuth, B. (Ed.), *Applications of Social Research Methods to Questions in Information and Library Science* (2nd ed., pp. 318–329). Oxford: Pearson Education.

Zhou, L., Almutairi, A., Alsaid, N., Warholak, T., & Cooley, J. (2017). Establishing the validity and reliability evidence of preceptor assessment of student tool. *American Journal of Pharmaceutical Education*, *81*(8), 10–20.

Ziv, A., Wolpe, P., Small, S., & Glick, S. (2003). Simulation-based medical education: An ethical imperative. *Academic Medicine*, *78*(8), 783–787.

Ziv, A., Wolpe, P., Small, S., & Glick, S. (2006). Simulation-based medical education: An ethical imperative. *Academic Medicine*, *78*(8), 783–787.

CURRICULUM VITAE

Barbie Ann Klein

EDUCATION

2013 – 2018   Doctor of Philosophy in Anatomy and Cell Biology
(Education Track)
Indiana University
- Dissertation: Simulation in medical education: A case study evaluating the efficacy of high-fidelity patient simulation

2011 – 2013   Master of Science in Human Anatomical Science
Northern Illinois University
- Master's research: Atlas of Thoracic and Abdominal Cadaver Dissection with Accompanying Histological Samples

2006 – 2008   Bachelor of Science in Cell and Developmental Biology
University of California Santa Barbara

2004 – 2006   Antelope Valley Community College
Lancaster, California

TEACHING EXPERIENCE

2017 – 2018   Human Embryology (M300)
Medical Sciences Program, Indiana University
- Role: Instructor of Record (Graduate Teaching Assistant)
- Credit hours: 3.0
- Responsibilities: I created all of the lecture content reviewing embryonic and fetal anatomy; developed all classroom activities and flipped classes; and wrote and graded formative quizzes and summative examinations.

2017   Special Topics in Biomedical Sciences (M490)
Medical Sciences Program, Indiana University
- Role: Instructor of Record (Graduate Teaching Assistant)
- Credit hours: 3.0
- Responsibilities: I redeveloped M300 Human Embryology to accommodate a small group discussion section.

2013 – 2018   Basic Human Anatomy (A215)
Medical Sciences Program, Indiana University
- Role: Graduate Teaching Assistant
- Credit hours: 5.0

- Responsibilities: I co-taught the laboratory portion of this course by presenting half of the laboratory topics; demonstrated cadaveric prosections and models; and assisted with set-up and grading of laboratory practical exams.

2016   Human Structure (MED X620)
        Medical Sciences Program, Indiana University
        - Role: Graduate Teaching Assistant
        - Credit hours: 8.0
        - Responsibilities: I performed cadaver prosections prior to each anatomy laboratory; assisted with student dissections; collaborated in creating formative and summative assessments for both anatomy and histology laboratories.

2015 – 2016   Gross Human Anatomy 1 and 2 (A550, A551)
        Medical Sciences Program, Indiana University
        - Role: Graduate Teaching Assistant
        - Credit hours: 8.0
        - Responsibilities: I performed cadaver prosections prior to each laboratory; assisted with student dissections; collaborated in creating formative and summative assessments; delivered one lecture each semester; and assisted in editing the online dissection guide.

2016   Human Anatomy for Medical Imaging Evaluation (A480/A580)
        Medical Sciences Program, Indiana University
        - Role: Graduate Teaching Assistant
        - Credit hours: 4.0
        - Responsibilities: I developed a rubric for weekly radiology blogs; graded blogs, quizzes, and exams; tutored students during laboratories and office hours; and created practice exams.

2015   Medical Neuroscience (M555)
        Medical Sciences Program, Indiana University
        - Role: Graduate Teaching Assistant
        - Credit hours: 5.0
        - Responsibilities: I assisted the instructor with laboratories demonstrating cadaveric specimens, MRIs, plastic-embedded sections, and light microscopy; assisted with laboratory exam development and exam review sessions, daily laboratory quizzes, and case studies; delivered one lecture and assisted with several small group exercises.

2014   Cell Biology and Histology (A560)
        Medical Sciences Program, Indiana University
        • Role: Graduate Teaching Assistant
        • Credit hours: 5.0
        • Responsibilities: I was responsible for all laboratory
          introductions, formative activities, and digital practicals
          exams; created an online activity for a flipped class and taught
          one lecture; graded all laboratory exams and facilitated
          reviews.

2012 – 2013   Functional Human Anatomy (BIOS 311)
        Biological Sciences Department, Northern Illinois University
        • Role: Graduate Teaching Assistant
        • Credit hours: 4.0
        • Responsibilities: I assisted in creation of all laboratory
          presentations and handouts; held additional review sessions;
          and assisted in development of all laboratory practicals.

2012 – 2013   Human Anatomy Short-Course for High School Students
        Biological Sciences Department, Northern Illinois University
        • Role: Graduate Teaching Assistant
        • Credit hours: N/A
        • Responsibilities: I was selected to assist with eight daylong
          anatomy immersion courses for local area high school anatomy
          and physiology classes; instructed students rotating through
          several stations including: bones, models, and prone and
          supine cadaveric prosections; assisted with the set up of a
          practical exam administered at the conclusion of the day.

2011 – 2012   Human Anatomy and Physiology (BIOS 357)
        Biological Sciences Department, Northern Illinois University
        • Role: Graduate Teaching Assistant
        • Credit hours: 5.0
        • Responsibilities: I taught all laboratory presentations and
          demonstrated anatomy models; created review presentations;
          assisted in creating practical exams; and held extra group
          tutoring sessions.

2008   Anatomy of the Musculoskeletal System (ESS 47)
        Exercise and Sports Studies Department, UC Santa Barbara
        • Role: Undergraduate Teaching Assistant
        • Credit hours: 4.0
        • Responsibilities: I was accepted as one of three undergraduate
          teaching assistants based on highest performance in ESS 47
          Fall 2007; I held weekly review sessions, tutored students, and
          proctored all quizzes and exams.

HONORS AND AWARDS

2018   Dr. Robert W. Bullard Award ($1,500)
Medical Sciences Program, Bloomington IN
Awarded to an outstanding student in the graduate curriculum

2017   Outstanding Associate Instructor Award ($1,000)
Medical Sciences Program, Bloomington IN
Awarded for excellent performance in undergraduate student education

2015   Paul M. Harmon Scholarship Award ($1,000)
Medical Sciences Program, Bloomington IN
Awarded for high standards of performance in Medical Physiology

2015 – 2018   American Association of Anatomists Student Travel Award ($350)

2014   Human Anatomy and Physiology Society Graduate Student Travel Award ($400)

2008   National Society of Leadership and Success Award
University of California Santa Barbara, Santa Barbara CA

2005   Lockheed Martin Aeronautics Scholarship ($200)
Antelope Valley College, Lancaster CA

2005   Dr. Shahid Khan Scholarship ($100)
Antelope Valley College, Lancaster CA

PROFESSIONAL AFFILIATIONS

2018 – Present   Society of Ultrasound in Medical Education (SUSME)

2016 – Present   Central Group on Educational Affairs, CGEA

2012 – Present   American Association of Anatomists

2012 – Present   American Association of Clinical Anatomists

2011 – Present   Human Anatomy and Physiology Society

PUBLICATIONS

BOOKS AND BOOK CHAPTERS

Klein, B. and Loyet, M. Yoga Anatomy: An Experiential Atlas. Thieme Medical Publishers, Inc. Writing in progress, anticipated date of release: late 2018.

Klein, B. Experimenting with a flipped class method of instruction. In Robinson, J., O'Loughlin, V., Kearns, K., Plummer, L. (Eds.), Voices from the Classroom (p. TBD). Bloomington, IN: Indiana University Press. Anticipated date of release: TBD.

REFERRED JOURNAL ARTICLES

Wilson, A., Brown, K., Misch, J., Miller, C., Klein, B., Taylor, M., Goodwin, M., Boyle, E., Hoppe, C., and Lazarus, M. Breaking with tradition: A scoping meta-analysis analyzing the effects of student-centered and computer aided instruction on student performance in anatomy. Accepted for publication in *Anatomical Sciences Education* March 2018.
doi: 10.1002/ase.1789

Wilson, A., Miller, C., Klein, B., Taylor, M., Goodwin, M., Boyle, E., Brown, K., Hoppe, C., and Lazarus, M. (2017). A meta-analysis of anatomy laboratory pedagogies. *Clinical Anatomy*, *31*, 122-133. doi: 10.1002/ca.22934

Sugrue, M., Klein, B., Loyet, M. (2017). Yoga anatomy workshops: Yoga as experiential learning in undergraduate anatomy courses. *HAPS Educator*, *21*(3), 65-74.

Wilson, A., Taylor, M., Klein, B., Sugrue, M., Whipple, E., and Brokaw, J. (2016). Meta-analysis and review of learner performance and preference: Virtual versus optical microscopy. *Medical Education*, *50*, 428-440. doi: 10.1111/medu.12944

ARTICLES

Klein, B. (2015). Review and summary of Dr. Dee Silverthorn's update seminar: The challenges of educational research, or navigating your way through grant proposals, reviewers, and IRBs on your way to a published project. *HAPS Educator*, *19*(3), 60-61.

Klein, B. (2014). First timer, first take. *HAPS Educator*, *18*(3), 20-21.

ABSTRACTS

Klein, B. (2016). Experiencing Embodied Learning: A Mixed-Methods Analysis of a Yoga Anatomy Workshop. Poster presentation at Experimental Biology AAA

Meeting in San Diego CA. *FASEB J*, *30*(1), 785.3. Also presented at IUPUI Anatomy and Cell Biology Fall Research Forum 2016.

Sugrue, M. Klein, B., and Loyet, M. (2016). Yoga Anatomy Workshops for Kinesthetic Learners. Oral presentation at Human Anatomy and Physiology Society Annual Conference in Atlanta GA. *HAPS Educator*, *20*(3), 129.

Klein, B. (2015). Flipping Histology: An Interactive Lymphatic Adventure. Oral presentation at Human Anatomy and Physiology Society Annual Conference in San Antonio TX. *HAPS Educator*, *19*(3), 94.

Loyet, M., Klein, B., and O'Loughlin, V. (2015). The Effectiveness of Using Yoga Asanas to Teach Musculoskeletal Anatomy to Undergraduate Students. Poster presentation at Human Anatomy and Physiology Society Annual Conference in San Antonio TX. *HAPS Educator*, *19*(3), 30.

Klein, B. (2015). Perceptions of a Flipped Histology Class: As Polarized as Politics? Poster presentation at Experimental Biology AAA Meeting in Boston MA. *FASEB J*, *29*, 546.6. Also presented at IUPUI Anatomy and Cell Biology Fall Research Forum 2016.

PRESENTATIONS

INVITED PRESENTATIONS

Klein, B. (2017). Exploring the effectiveness of a flipped class using game-based learning. Oral presentation at Experimental Biology AAA Meeting in Chicago IL. *FASEB J*, *31*, 93.2

REFEREED PRESENTATIONS

Klein, B. and Loyet, M. (2017). Numerous and Sometimes Naughty: The Use of Mnemonics in Anatomy Education. Oral presentation at the Human Anatomy and Physiology Society Annual Conference in Salt Lake City UT.

Klein, B. (2016). Teaching with Tablets: Comparing Undergraduate Perceptions of PowerPoint Slides to a Dynamic Digital Whiteboard in a Human Anatomy Laboratory. Poster presentation at the Human Anatomy and Physiology Society Annual Conference in Atlanta GA.

Cassidy, K. and Klein, B. (2016). Evaluation of an Interactive Histology Review Session for Medical Student Statewide Exam Preparation. Poster presentation at IUPUI Edward C. Moore Symposium on Excellence in Teaching, March 25.

Wilson, A., Taylor, M., Klein, B., Sugrue, M., Whipple, E., and Brokaw, J. (2015). The Effects of Virtual Microscopy on Learner Performance: A Meta-analysis. Poster

presentation at AAA Fall Regional Meeting in Milwaukee, WI.

Klein, B. (2014). Atlas of Thoracic and Abdominal Cadaver Dissection with Accompanying Histological Samples. Poster presentation at Human Anatomy and Physiology Society Annual Conference in Jacksonville FL.

PROFESSIONAL AND UNIVERSITY SERVICE

2016 – 2018	Student Associate Editor, *HAPS Educator* Human Anatomy and Physiology Society (HAPS) • Responsibilities: I work as an acquisitions editor for new submissions from graduate students; and oversee the review process for Educational Research category articles.
2014 – Present	*HAPS Educator* Journal Committee Member Human Anatomy and Physiology Society (HAPS) • Responsibilities: I assist in the editorial process; contributed to discussions regarding the scope and future directions for the journal; and created a revised submission form for reviewers.
2017	Contemporary Ideas about Teaching and Learning Associate Instructor (AI) Orientation Workshop Co-presenter Center for Innovative Teaching and Learning (CITL), Indiana University • Responsibilities: I collaborated with three other graduate students to prepare an interactive presentation for new graduate student instructors about constructivism, brain-based learning, student-centered instruction, active learning, assessment, and feedback.
2016 – 2017	Textbook Reviewer for Gilroy, A. and MacPherson, B. (2016) Atlas of Anatomy, 3rd edition, and the accompanying online dissection guide. Thieme Medical Publishers, Inc.
2016	Introduction to Theories of Learning and Teaching Associate Instructor (AI) Orientation Workshop Co-presenter Center for Innovative Teaching and Learning (CITL), Indiana University • Responsibilities: I collaborated with three other interdepartmental graduate students to prepare a presentation about six common teaching and learning myths. I also hosted a lunch session discussing formative assessment strategies to incorporate during laboratories.
2016	Medical Physiology Problem-based Learning (PBL) Facilitator Medical Sciences Program, Indiana University

2016   Chapter Reviewer for van Lessen and Hager-Forstenlechner, <u>Medical Yoga Professional: Spiral Dynamics Meets Hatha Yoga</u>. Thieme Medical Publishers, Inc.

2016   Chapter Reviewer for Lamprecht, <u>Training in Neurorehabilitation</u>. Thieme Medical Publishers, Inc.

2016   Software Reviewer for NetAnatomy by Scholar Educational Systems, Inc.

2015 – 2016   Preparing Future Faculty Conference 2016 Volunteer
Indiana University Bloomington
- <u>Responsibilities</u>: I participated in planning meetings, distributed flyers, helped create information packets, and assisted with registration during the event.

2015   Kindergarten Anatomy Lesson
Jack Northrop Elementary School, Lancaster, CA
- <u>Responsibilities</u>: I visited five kindergarten classes to teach a grade-level appropriate anatomy lesson. I used SMART Board technology to introduce five major organs before guiding students to apply the material in a crafting activity.

PROFESSIONAL DEVELOPMENT

2017   Three Minute Thesis Competition Participant (March 9)
The Indiana University Graduate School, Bloomington IN
- I participated in a research communication competition among graduate students to present their research in three minutes or less.

2015   Gross anatomy cadaver prosector (May – August)
Medical Sciences Program, Indiana University
- I performed one complete cadaveric prosection and donor report noting physical and pathological findings.

2015   An Introduction to Evidence-Based Undergraduate STEM Teaching Coursera.org MOOC (August – December)
- I participated in a weekly Learning Community, watched assigned videos, took weekly quizzes, and participated in group discussions.

2014   Techie Woman Have More Conference (March 6-7)
Center of Excellence for Woman in Technology (CEWiT), Indiana University, Bloomington IN

2013	Indiana University Biology Department New Associate Instructor Orientation (August 21-23)
2013	Indiana University CITL Preparing Future Faculty Associate Instructor Orientation (August 20)
2012	Faculty Development and Instructional Design Graduate Teaching Certificate (August 30) Northern Illinois University, DeKalb IL
2012	Accepted as a Participant in the International Human Cadaver Prosection Program (July 31 – August 2) Indiana School of Medicine Northwest, Gary IN
2011	Northern Illinois University Department of Biological Sciences Teaching Assistant Orientation (August 16-17)
2011	Gross anatomy cadaver prosector Northern Illinois University, DeKalb IL

- I assisted my Gross Human Anatomy professor with extra cadaver dissections, acquiring over 50 hours of dissection experience.