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The Effect of High-Fidelity Manikin-Based Human Patient Simulation on Educational Outcomes in Advanced Cardiovascular Life Support Courses

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THE EFFECT OF HIGH-FIDELITY MANIKIN-BASED HUMAN PATIENT SIMULATION ON EDUCATIONAL OUTCOMES IN ADVANCED CARDIOVASCULAR LIFE SUPPORT COURSES

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ABSTRACT

The Effect Of High-Fidelity Manikin-Based Human Patient Simulation On Educational Outcomes In Advanced Cardiovascular Life Support Courses

The use of high-fidelity manikin-based simulation has been studied in many healthcare education areas. However, the use of this education technology in the American Heart Association Advanced Cardiovascular Life Support (ACLS) course has not been well examined in the literature, despite this education program being one of the most widely taught standardized medical courses in the United States. This study examined high-fidelity manikin-based simulation versus low-fidelity manikin-based simulation in the context of an actual ACLS course. Four outcomes were measured: learning outcomes as judged by an expert rater panel reviewing videos of subjects performing a simulated cardiac arrest event immediately after the conclusion of the course, and three self-reported measures examining confidence with the course material, motivation, and affect. A convenience sample of 34 subjects self assigned to one of two ACLS classes. One class utilized high-fidelity simulation (n=16) while the other used low-fidelity simulation (n=18). While the high-fidelity simulation group had a higher composite score for the video review (M= 220.88 vs. M=193.67), this did not reach a level of significance (p=.122). On item level analysis of the scoring, 7 of 14 items reached levels of significance ($p < .05$). Although all items reported higher mean scores for the high-fidelity simulation group, items that focused on manual tasks or actions in the first one to two minutes of the cardiac arrest event were more likely to be non-significant. Items that focused on actions that occurred later in the event or were expert rater assessments of team leader confidence and knowledge were more likely to be found significant. There was no statistical significance found in any of the self-reported measures examining confidence (p = .850), motivation (p = .899), and affect (p = .215).

DEDICATION

It is with great admiration and love that I dedicate this dissertation to my wife Robin. Her support was crucial in helping me achieve this goal. Her willingness to tolerate the time I spent at the computer writing or scouring the library for just one more article was greatly appreciated.

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CHAPTER ONE: INTRODUCTION

Technology has become an important part of many classrooms. Health professions education is no different. One relatively recent technology in the health professions classroom is the use of high-fidelity manikin-based patient simulators. These devices replicate many human physiological functions and anatomical features. Learners interact with the simulator, discovering critical assessment information in the same manner they would with real patients. Once the simulator's medical condition is identified, learners then proceed with treatment options in an effort to correct the simulator's condition.

Manikin-based patient simulators of varying degrees of fidelity have been used in health professions teaching and been examined or reviewed in a variety of clinical areas including:

- emergency medicine (Bond et al., 2004; Bond et al., 2006; Bond & Spillane, 2002; Ellis & Hughes, 1999; Euliano & Mahla, 1999; Jones, Hunt, Carlson, & Seamon, 1997; Kobayashi et al., 2006; McLaughlin, Doezema, & Sklar, 2002; Reznek et al., 2003; J. Sanders, Haas, Geisler, & Lupien, 1998; Shapiro et al., 2004; Treloar, Hawayek, Montgomery, & Russell, 2001; Vozenilek, Wang, Kharasch, Anderson, & Kalaria, 2006; Wang & Vozenilek, 2005),
- trauma (Barsuk et al., 2005; Block, Lottenberg, Flint, Jakobsen, & Liebnitzky, 2002; Gilbart, Hutchison, Cusimano, & Regehr, 2000; Hammond, 2004;

Hendrickse, Ellis, & Morris, 2001; Holcomb et al., 2002; Lee et al., 2003; Marshall et al., 2001),

- pre-hospital care (Bond, Kostenbader, & McCarthy, 2001; Hall et al., 2005; LeBlanc, MacDonald, McArthur, King, & Lepine, 2005),
- in-hospital care (DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Lighthall et al., 2003; Mayo, Hackney, Mueck, Ribaudo, & Schneider, 2004; St Clair, Oddone, Waugh, Corey, & Feussner, 1992; Wayne et al., 2005),
- pediatrics (Fiedor, 2004; Goodwin, van Meurs, Sa Couto, Beneken, & Graves, 2004; Halamek et al., 2000; Palmisano, Akingbola, Moler, & Custer, 1994; S. W. Roberts & McCowan, 2004; Tsai, Harasym, Nijssen-Jordan, Jennett, & Powell, 2003; Yaeger et al., 2004),
- obstetrics (Bonin & Posner, 2004; Deering, Brown, Hodor, & Satin, 2006; Deering et al., 2006; Deering, Poggi, Macedonia, Gherman, & Satin, 2004; Dupuis et al., 2005; Euliano, Caton, van Meurs, & Good, 1997; Gurewitsch et al., 2005; Macedonia, Gherman, & Satin, 2003; Pittini et al., 2002; Robertson, 2006),
- and anesthesia (Abrahamson & Denson, 1969; Abrahamson, Denson, & Wolf, 1969; Berkenstadt et al., 2003; Blum, Raemer, Carroll, Dufresne, & Cooper, 2005; Blum et al., 2004; Cleave-Hogg & Morgan, 2002; Coopmans, 2005; Dalley, Robinson, Weller, & Caldwell, 2004; DeAnda & Gaba, 1991; Denson & Abrahamson, 1969; Detty Oswaks, 2002; Euliano & Good, 1997; Euliano, Lampotang, & Hardcastle, 1995; Euliano, Mahla, & Banner, 1998; Fallacaro, 2000; Farnsworth, Egan, Johnson, & Westenskow, 2000; Fletcher, 1995; Forrest, Taylor, Postlethwaite, & Aspinall, 2002; Gaba & DeAnda, 1988; Grant, 2002;

Graydon et al., 2000; Henrichs, Rule, Grady, & Ellis, 2002; Hogan, 2004; Hotchkiss & Mendoza, 2001; Howard, Gaba, Fish, Yang, & Sarnquist, 1992; Loyd, 2004; Lupien, 2004; Monti, Wren, Haas, & Lupien, 1998; Morgan & Cleave-Hogg, 1999, 2000; W. B. Murray, Good, Gravenstein, van Oostrom, & Brasfield, 2002; W. B. Murray & Schneider, 1997; Norman & Wilkins, 1996; Register, Graham-Garcia, & Haas, 2003; Rosenblatt & Abrams, 2002; Schwid et al., 2002; Sinz, 2005; Sorenson, 2002; Via, Kyle, Trask, Shields, & Mongan, 2004; Watterson, Flanagan, Donovan, & Robinson, 2000; J. Weller et al., 2003; A. K. Wong, 2004; Yee et al., 2005).

Additionally, teaching with manikin-based patient simulation has involved many levels of health professions students and practitioners including:

- nurses (Alinier, Hunt, Gordon, & Harwood, 2006; Aronson, Rosa, Anfinson, & Light, 1997; Bearnson & Wiker, 2005; Bremner, Aduddell, Bennett, & VanGeest, 2006; Diefenbeck, Plowfield, & Herrman, 2006; Feingold, Calaluce, & Kallen, 2004; Ferguson, Beerma, Eichorn, Jaramillo, & Wright, 2004; Fontaine & Norton, 2001; Griggs, 2003; Haskvitz & Koop, 2004; Hravnak, Tuite, & Baldisseri, 2005; Larew, Lessans, Spunt, Foster, & Covington, 2006; Lasater, 2005; Nehring, Ellis, & Lashley, 2001; Nehring & Lashley, 2004; Rauen, 2001, 2004; Ravert, 2004; Robertson, 2006; Scherer, Bruce, Graves, & Erdley, 2003; Schumacher, 2004a, 2004b; Spunt, Foster, & Adams, 2004; Yaeger et al., 2004),
- medical students (Bowyer et al., 2006; Cleave-Hogg & Morgan, 2002; Collins & Harden, 1998; Deering et al., 2006; Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001; Euliano, 2000, 2001; Ewy et al., 1987; Gilbart, Hutchison, Cusimano, & Regehr,

2000; Goodrow, Rosen, & Wood, 2005; J. A. Gordon, 2002; J. A. Gordon, Oriol, & Cooper, 2004; J. A. Gordon & Pawlowski, 2002; J. A. Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Issenberg, Petrusa et al., 1999; Issenberg, Pringle, Harden, Khogali, & Gordon, 2003; Lane, Slavin, & Ziv, 2001; McKenzie, 2004; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005; Morgan & Cleave-Hogg, 1999, 2000, 2002; Morgan, Cleave-Hogg, Desousa, & Lam-McCulloch, 2006; Morgan, Cleave-Hogg, McIlroy, & Devitt, 2002; Morgan, Cleave-Hogg, Guest, & Herold, 2001; D. Murray et al., 2002; Rogers, Jacob, Rashwan, & Pinsky, 2001; Steadman et al., 2006; Tan, Ti, Suresh, Ho, & Lee, 2002; Treadwell & Grobler, 2001; Via, Kyle, Trask, Shields, & Mongan, 2004; J. Weller, 2004; J. Weller, Robinson, Larsen, & Caldwell, 2004; Woolliscroft, Calhoun, TenHaken, & Judge, 1987),

- resident physicians (Abrahamson & Denson, 1969; Abrahamson, Denson, & Wolf, 1969; Bond et al., 2004; Bond et al., 2006; Bond & Spillane, 2002; Byrick, Cleave-Hogg, & McKnight, 1998; Deering, Brown, Hodor, & Satin, 2006; Deering et al., 2006; Deering, Poggi, Macedonia, Gherman, & Satin, 2004; Denson & Abrahamson, 1969; Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001; Euliano & Mahla, 1999; Gisondi, Smith-Coggins, Harter, Soltysik, & Yarnold, 2004; Hammond, Bermann, Chen, & Kushins, 2002; Howard, Gaba, Fish, Yang, & Sarnquist, 1992; Issenberg, Gordon, & Greber, 2003; Issenberg et al., 2002; Lee et al., 2003; Lighthall et al., 2003; Loyd, 2004; Marshall et al., 2001; McLaughlin, Doezema, & Sklar, 2002; Reznek et al., 2003; Savoldelli et al., 2006; Schwid et al., 2002; Tsai, Harasym, Nijssen-Jordan, Jennett, & Powell, 2003; Wackett, Anderson, & Thode, 2005; Wang & Vozenilek, 2005; Wayne et al., 2005; Yee et al., 2005),

- practicing physicians (Block, Lottenberg, Flint, Jakobsen, & Liebnitzky, 2002; Blum et al., 2004; Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001; M. S. Gordon et al., 1981; Rosenblatt & Abrams, 2002; J. Weller, Dowell, Kljakovic, & Robinson, 2005),
- and multidisciplinary healthcare teams (DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Holcomb et al., 2002; Marsch et al., 2005; Palmisano, Akingbola, Moler, & Custer, 1994; Raemer & Barron, 1997; Shapiro et al., 2004).

Yet, despite early suggestions on the utility of using high-fidelity manikin-based simulation in ACLS programs (Kapur & Steadman, 1998), the actual application of high-fidelity manikin-based patient simulation into one of the most common and long-standing multidisciplinary medical training programs in the United States has not been well examined. The American Heart Association (AHA) Advanced Cardiovascular Life Support (ACLS) training program was first conducted in 1974 and now is a common training program used to teach advanced level healthcare providers the skills and knowledge needed to respond to critical cardiopulmonary emergencies. Several studies have been conducted using high-fidelity manikin-based patient simulators in ACLS-like courses or using ACLS level skills (DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Mayo, Hackney, Mueck, Ribaudo, & Schneider, 2004; O'Brien, Haughton, & Flanagan, 2001; Schwid & O'Donnell, 1992; Wayne et al., 2005). However, no study on the efficacy of high-fidelity manikin-based patient simulation as compared to traditional training with low-fidelity manikins in the context of an actual ACLS course has been published.

Background

American Heart Association Advanced Cardiovascular Life Support Course

The American Heart Association was founded in 1924 and is now the largest voluntary healthcare organization in the United States. The mission of the AHA is “to reduce disability and death from cardiovascular diseases and stroke ("Mission of the American Heart Association", 2006).” To help support that mission, the AHA promotes classes in Emergency Cardiovascular Care (ECC). These classes include programs in Basic Life Support (cardiopulmonary resuscitation or CPR), Pediatric Advanced Life Support (PALS), and Advanced Cardiovascular Life Support. Nearly 10 million people were trained in American Heart Association ECC courses in 2005, with the majority of these being healthcare providers (*Making connections: Annual report 2005*, 2006). In 2005, 702,995 individuals completed training in American Heart Association Advanced Cardiovascular Life Support (personal communication from Alan Carrington, American Heart Association, Aug. 4, 2006).

ACLS is typically taught as a one- or two-day course (8 - 16 hours of classroom instruction), depending on the level of experience of the healthcare provider or if the program is for initial certification or renewal certification. The American Heart Association states:

> The ACLS Provider Course is designed to teach providers the knowledge and skills needed to evaluate and manage the first 10 minutes of an adult VF/VT [Ventricular Fibrillation/Ventricular Tachycardia] arrest. Students are expected to

> learn to manage 10 core ACLS cases: respiratory emergency, 4 types of cardiac arrest (simple VF/VT, complex VF/VT, PEA [Pulseless Electrical Activity], and asystole), 4 types of prearrest emergencies (bradycardia, stable tachycardia, unstable tachycardia, and acute coronary syndromes), and stroke. ("ACLS provider course", 2006)

Developed in 1973 by Stephen Carveth and colleagues with the Lincoln (NE) Medical Education Foundation, ACLS first started as a cardiac dysrhythmia recognition course for emergency department personnel (Carveth et al., 1976; Collicott, 2005). ACLS – known as Advanced Cardiac Life Support at the time – eventually became the first advanced standardized national program designed to teach responders how to manage cardiac arrest victims. It was formally introduced at the annual convention of the American Medical Association in Chicago in June, 1974 (Carveth, 1974; Carveth et al., 1976). The American Heart Association began a sponsorship of the course (initially with the American Medical Association and the American Society of Anesthesiologists) at a course conducted in Portland, OR, in November 1974. The Portland course also was the first course that provided certification upon successful completion (Carveth et al., 1976). Since its development, the ACLS course has served as the template for other short-courses in resuscitation, including the American College of Surgeons Advanced Trauma Life Support (ATLS) course (Collicott & Hughes, 1980).

Since then, the ACLS course has changed greatly. Originally introduced as a very instructor-centric program, the course initially was lecture driven with very little hands-on practice time, a model that did generate some criticisms (Atkins, 1986) . In its current form, the ACLS course has become much more student-focused with an emphasis on immersive practice time with considerable opportunity for hands-on application. The course features a case-based approach that allows introduction of course content in contextual case presentations that require students to interact with the case in order to find a desirable outcome and achieve the learning objectives. The role of the instructor has shifted more to a facilitator as he or she guides the students through the content. Validation of performance is achieved at the conclusion of the course through a written evaluation and a case-based assessment, traditionally called the Mega Code station, which involves the student leading a team of healthcare providers through a cardiopulmonary crisis event. While the American Heart Association provides instructors with sample course agendas, some minor modifications for local issues are allowed. The ACLS course agenda used in this program is shown in Appendix A.

The ACLS course targets healthcare providers who may have a responsibility to respond to critical cardiopulmonary emergencies. This includes, “Emergency, intensive care, or critical care personnel; emergency medical providers such as physicians, nurses, EMTs, paramedics, respiratory therapists; and other professionals who may need to respond to a cardiovascular emergency ("ACLS provider course", 2006).”

The newest version of the ACLS course was introduced in September 2006. It is this version of the program examined in this study. The American Heart Association states the following as the current course goals in ACLS:

> The Advanced Cardiovascular Life Support (ACLS) Provider Course is designed for healthcare providers who either direct or participate in the resuscitation of a patient, whether in- or out-of-hospital. The goal of the ACLS Provider Course is

to improve the quality of care provided to the adult victim of cardiac arrest or other cardiopulmonary emergency.

In this course your students will enhance their skills in the treatment of arrest and peri-arrest patients through active participation in a series of simulated cardiac and respiratory cases. These simulations are designed to reinforce important concepts, including:

- Basic life Support (BLS) Primary Survey
- The ACLS Secondary Survey
- ACLS algorithms
- Effective resuscitation team dynamics

(*Advanced Cardiovascular Life Support Instructor's Manual*, 2006, p. 4)

Specific learning objectives for the course are detailed in the ACLS Instructor’s Manual as follows:

- Recognize and initiate early management of peri-arrest conditions that may result in cardiac arrest or complicate resuscitation outcomes
- Demonstrate proficiency in providing BLS [Basic Life Support] care, including prioritizing chest compressions and integrating AED [Automated External Defibrillator] use
- Manage cardiac arrest until the return of spontaneous circulation, termination of resuscitation, or transfer of care
- Identify and treat ischemic chest pain and expedite the care of patients with acute coronary syndromes

- Recognize other life threatening clinical situations, such as stroke, and provide effective initial care and transfer to reduce disability and death
- Demonstrate effective communication as a member or leader of a resuscitation team and recognize the impact of team dynamics on overall team performance

(*Advanced Cardiovascular Life Support Instructor's Manual*, 2006, p. 4)

Development of Manikin-Based Patient Simulation Technology

The history of simulation in healthcare has been well documented by several authors including Bradley (2006), Cooper and Taqeuto (2004), Gaba (2004a), and Rosen (2004). While simulation has been used in many industries, simulation in healthcare often refers to aviation simulation as a model to emulate (Friedrich, 2002; Gaba & DeAnda, 1988; J. A. Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Halamek et al., 2000; Hamman, 2004a, 2004b; Henriksen & Moss, 2004; Hotchkiss & Mendoza, 2001; Shaffer et al., 2001; A. K. Wong, 2004; S. H. Wong, Ng, & Chen, 2002). Shaffer et al. (2001) offered this explanation as to why the fields of aviation and medicine share similar ties to simulation:

> "Expert domains" like aviation and medicine are characterized by unstructured problems, where a potentially unlimited number of features are related in unclear and complex ways. Theorists argue that skill development in such domains requires practical experience, rather than abstract "book learning." Pilots and physicians must develop finely-tuned perceptual and motor skills, the ability to analyse complex situations quickly and accurately, based on limited information,

and the ability to make sound decisions about how to proceed, based on their assessment of the tactical or clinical information. (p. 76-77)

The origins of aviation simulation are tied to Edwin Link who developed the first aircraft simulator, patenting the device in 1929. By the 1950's, Link had connected his simulator to analog computer devices to provide feedback information to student pilots. Link's rather simple invention in 1929 has since evolved into the highly complex flight simulators in use today in aviation and space. Interestingly, Link took his simulation experience into other fields, including the development of the first power plant simulator in the early 1970s.

Simulation in healthcare has a long history, although the use of manikins to serve as the simulation model is relatively new (Bradley, 2006). Simulation using animals as models dates back over 2000 years. Manikins were utilized as models in obstetrical care as early as the 16th century (Ziv, Wolpe, Small, & Glick, 2003). Manikins for the purpose of teaching medical procedures were introduced as a commercial product in 1911 with the Chase Hospital Doll – usually referred to as "Mrs. Chase." These life-size manikins were primarily designed to teach basic nursing care and as early as 1915, models were introduced that allowed for the practice of injections and urinary catheterization ("Connecticut nursing history vignettes", 2004).

However, the use of manikins as models for the purposes of practicing resuscitation medical procedures was not introduced as a widespread commercial product until 1960 when Asmund Laerdal, a Norwegian toy maker, was approached by a group of Norwegian anesthesiologists lead by Bjorn Lind to create a manikin for teaching mouth-to-mouth ventilations. With additional input from Peter Safer, an Austrian-born US-based anesthesiologists, Laerdal Medical's manikin was modified to allow for the application of chest compressions. Introduced in 1960, the Laerdal Resusci Anne manikin was the first manikin specifically built to teach resuscitation skills.

The first computer controlled manikin-based patient simulator was introduced in 1967. SimOne was developed at the University of Southern California by a team lead by Stephen Abrahamson and Judson Denson. SimOne had many of the features found on the high-fidelity manikin-based patient simulators used today. As described by Abrahamson:

> SimOne was quite lifelike in appearance, having a plastic skin which resembled that of a real (Caucasian) human being in color and texture. He (it was a male) had a configuration of a patient lying on an operating-room table with (1) his left arm extended and fitted with an intravenous port ready for intravenous injection; (2) his right arm fitted with a blood pressure cuff; and (3) his chest having a stethoscope taped over the approximate location of his heart. SimOne breathed, had a heartbeat, temporal and carotid pulses (all synchronized), and blood pressure. He was able to open and close his mouth, blink his eyes, and respond to four intravenously administered drugs and two gases (oxygen and nitrous oxide) administered through mask or tube (Abrahamson, 1997, p. 29).

The first appearance of SimOne in the medical literature was in 1969 with articles by Denson and Abrahamson (1969) and Abrahamson, Wolf, and Denson (1969). From its first appearance in the literature, SimOne set the stage for patient simulation as it is being conducted today. Denson and Abrahamson (1969) asked a series of questions as they opened their first published study;

> Suppose a student could learn the necessary manual skills before his first examination of a patient. Suppose he could learn these skills in a planned, systematic orderly way. Suppose he could learn them rapidly in hours or days rather than months. How much saving in instructor time and mental anxiety could be achieved? And, all of this with greatly reduced hazard or discomfort for how many patients? Could the use of simulation techniques answer these questions affirmatively? (p. 504).

Despite these questions being posed in 1969, these questions are still being asked today.

In their later article of that year, Abrahamson, Wolf, and Denson (1969) described an experimental study showing the device was useful in the teaching of anesthesia residents. The authors summarized their findings:

> Despite the lack of statistical significance in several of the analyses, the investigators conclude that there is an advantage in time in the use of this computer-controlled patient simulator in the training of anesthesiology residents. Residents using the simulator tend to arrive at accepted professional levels of performance in fewer elapsed days and in a smaller number of trials in the operating room than do residents who did not have a training period on the simulator. (p. 57)

Hoffman and Abrahamson (1975) stated that SimOne demonstrated cost-effectiveness in several areas of medicine. These included induction of anesthesia, recovery room care, and pulse and respiration measurement. In evaluating the factors that contribute to cost savings in training, Hoffman and Abrahamson made the following comments:

When the cost-effectiveness of SimOne is assessed, the evaluator must consider not only decreases in faculty and student time and gains in student performance but also the number and frequency of personnel groups in need of training. Taking all these factors into account, data from these studies indicate a cost savings with the use of SimOne are such to justify its cost within a short period of time. (p. 1128)

Even with the potential offered by these early studies, SimOne was never an economically viable endeavor and no commercial outlet was ever established. After nearly 10 years of use, the one-of-a-kind device began to fall into a worsening state and eventually was evicted from its laboratory, making its demise complete.

At approximately the same time as SimOne was being developed in Los Angeles, another group of physicians and engineers was developing a different patient simulator in Miami, Florida. While not able to meet the strictest definition of a full-bodied high-fidelity manikin-based patient simulator, the "Harvey" cardiology simulator provided several innovations that were critical to the development of the high-fidelity manikin-based patient simulators in use today. Harvey was introduced in 1968 and featured:

… various physical findings, including blood pressure by auscultation, bilateral jugular venous pulse wave forms and arterial pulses, precordial impulses, and auscultatory events in the four classic areas; these are synchronised with the pulse and vary with respiration. Harvey is capable of simulating a spectrum of cardiac disease by varying blood pressure, breathing, pulses, normal heart sounds, and murmurs (J. Cooper & Taqueti, 2004, para 13).

Unlike SimOne, Harvey was able to be produced commercially and was integrated in healthcare professions education at institutions around the world. It is still being produced today. Importantly, Harvey was also able to make a significant contribution to the research literature and is featured in several peer-reviewed studies and articles that showed that simulation in cardiopulmonary assessment was beneficial (M. S. Gordon, Ewy, DeLeon et al., 1980; M. S. Gordon, Ewy, Felner et al., 1980; M. S. Gordon et al., 1981; M.S. Gordon, Issenberg, Mayer, & Felner, 1999; Issenberg, Gordon, Gordon, Safford, & Hart, 2001; Issenberg, Gordon, & Greber, 2003; Issenberg, Pringle, Harden, Khogali, & Gordon, 2003; Jones, Hunt, Carlson, & Seamon, 1997; Karnath, Thornton, & Frye, 2002; St Clair, Oddone, Waugh, Corey, & Feussner, 1992; Woolliscroft, Calhoun, TenHaken, & Judge, 1987).

In 1986, David Gaba and Abe DeAnda developed the Comprehensive Anesthesia Simulation Environment (CASE) at Stanford University. Gaba worked with partner organization CAE-Link (a descendent of the original Link aviation simulation company) to license CASE technology and develop a commercially viable product in 1992. This product was later acquired by MedSim and marketed as the MedSim-Eagle. MedSim later terminated production and support in part due to a failed business strategy of creating training centers (J. Cooper & Taqueti, 2004).

The MedSim-Eagle did offer several technological advances over the SimOne system. Physical characteristics included:

> … airway anatomy that could be altered to mimic degrees of difficulty of intubation, palpable carotid and radial pulses, lungs that simulated behaviour during spontaneous and controlled ventilation, heart and breath sounds, eyes that

> opened and closed, and a thumb twitch, as used for monitoring neuromuscular blockade during anaesthesia. (J. Cooper & Taqueti, 2004, para 27)

Additionally, the MedSim-Eagle incorporated software developed by Howard Schwid at the University of California San Diego for a program there named the Anesthesia Simulator Consultant (ASC). The ASC software, coupled with the capabilities of the CASE system, provided a wide range of physiological models including, "cardiovascular and respiratory function, acid-base balance, and pharmacokinetics and pharmacodynamics representing numerous disease states (J. Cooper & Taqueti, 2004, para 27)."

Concurrent with the development of the CASE system, Michael Good and Joachim Gravenstein at the University of Florida developed the Gainesville Anesthesia Simulator (GAS). This simulator featured physical simulation of respiratory gas exchange. Additional enhancements to the GAS device included physiological and pharmacological mathematic models. GAS technology was licensed by Loral Data Systems, who later spun the division off into its own entity – Medical Education Technologies, Inc. (METI).

METI introduced the Human Patient Simulator (HPS) in 1996. It has subsequently followed with PediaSim in 1999, a simulator utilizing the HPS software but scaled down to mimic a child. In 2005, BabySim was introduced. The METI HPS represents the highest performance potential of any manikin-based patient simulator currently on the market (Lane, Slavin, & Ziv, 2001). METI recently introduced the Emergency Care Simulator (ECS). The ECS is a more portable unit than the HPS. It does not have all of the features found on the HPS, but provides sufficient high fidelity for the simulation of many medical emergency situations.

While being the first to enter the market with a full-bodied manikin for patient simulation purposes in resuscitation with the Resusci Anne in 1960, Laerdal Medical did not introduce a high-fidelity manikin-based patient simulator until 2000 with the introduction of SimMan. This device does not possess all the high-level functionality of the MedSim-Eagle or the METI HPS, but does provide adequate fidelity for many medical emergency situations and is similar to the METI ECS in its capabilities. The Laerdal Medical SimMan also differs from the others in that it does not operate on mathematical models for simulator responses. Instead, it operates on instructor controls coupled with script-based control logic. The Laerdal Medical SimMan patient simulator is the device to be used in this study. Details of the simulator's functions are found in Appendix B.

There have been other high-fidelity manikin-based simulators introduced. Among the most complex is the Leiden Anesthesia Simulator. This simulator was introduced in 1994 by the University of Leiden, Netherlands, and remains a one-of-a-kind device (Chopra, Engbers et al., 1994; Chopra, Gesink et al., 1994). Very recently, other commercially produced medium- to high-fidelity manikin-based simulators have been introduced. These include the HAL Mobile Team Trainer (Gaumard Scientific Company, Inc., Miami, FL) and the PDA STAT Manikin (Nasco, Inc., Fort Atkinson, WI).

Aside from high-fidelity manikin-based patient simulators, there are many others types of simulation used in healthcare provider education and training. Collins and Harden (1998), Issenberg, Gordon, Gordon, Safford, and Hart (2001), Lane, Slavin, and

Ziv (2001), Maran and Glavin (2003), Miller (1987) and Ziv, Small, and Wolpe (2000) discussed several other forms of simulation. Their compiled list includes:

- Animal models – While having a long history of use in the education of healthcare professionals, animal models are used with much less frequency due to growing ethical concerns and costs.
- Human cadavers – Used for procedure simulation, cadavers provide very realistic simulations for certain skills. However, limited availability and costs often make this a prohibitive teaching tool.
- Standardized patients – Real people portray patients with scripted or outlined responses to the healthcare provider's questions or physical examination. While standardized patients supply very high realism for skills such as communication, it is not possible to perform invasive procedures.
- Written simulations – Paper and pencil gaming techniques that provide basic information to simulate return of cognitive knowledge.
- Computer-based clinical simulations – Computer-based representations of patients designed to determine or test clinical decision-making.
- Audio simulations – Designed to teach auscultation assessment procedures.
- Video-based simulations – Designed primarily as demonstration tools to present information on examinations techniques, dynamic processes, and communication skills.
- Three-dimensional or static models – These models, also called anatomic-pathologic simulators, can range from simple reproductions of anatomy to more

complex models that allow for practice of procedures or assessment of anatomy or pathology.

- Task-specific simulators – Designed to teach specific skills or tasks such as cardiac catheterization surgical sills or laparoscopic surgical skills, these devices provide some level of virtual simulation through computer graphics.
- Virtual reality simulation – Provides an immersive computer-generated virtual world in which to conduct assessment and management of patients.

Another general classification of patient simulators that combines some of the elements of both three-dimensional models and task-specific simulators is partial- (or part-) task simulators (Sinz, 2004). Issenberg, Gordon, Gordon, Safford, and Hart (2001) used the term procedure skills simulator for this type of device. Maran and Glavin (2003) stated, "Part task trainers are designed to replicate only part of the environment (p. 24)." Partial-task simulators do not require the simulator to be a whole representation of the body with physiological responses that affect the whole body. Instead, partial-task simulators replicate anatomy and, in some cases, physiology of a single portion of the human body. As described by Beaubien and Baker (2004), the skills taught with part task simulators "segment a complex task into its main components (p. i53)." Rather than creating complex scenarios commonly done with high-fidelity manikin-based patient simulation, or as Beaubien and Baker described as full mission simulation, partial task trainers permit students to focus on individual skills instead of more comprehensive situations. Examples given by Miller (1987) included "the foot (to detect foot deformities), the knee (to isolate sports injuries), the rectum and colon (to practice physical examination skills and detect bowel disease), and the pelvis (to diagnose pregnancy or to practice obstetrical maneuvers during delivery (p. 37)". Other examples would be an arm with vascular structure to teach intravenous access procedures or a head with upper airway anatomy to practice advanced airway procedures.

Referring to comprehensive patient simulators, Gaba (2004b) explained a patient simulator was a "system that presents a fully interactive patient and an appropriate clinical work environment (p. i5)." He further elaborated that one of three presentations of this patient were possible: having the "patient" fully present as in manikin-based simulators, having the patient represented on a computer screen as in screen-based simulators, and presenting the patient in a more immersive computer-generated environment as in virtual reality simulators.

While these other forms of simulation do not offer the capabilities or utility of high-fidelity manikin-based patient simulators as used in this study, they have made significant contributions to the literature. Much of this data can be extrapolated to show support for the use of high-fidelity manikin-based patient simulation.

The cost of simulation is related to the level of fidelity and the technology being employed. For high-fidelity manikin-based patient simulators, acquisition costs can range from $30,000 for the Laerdal Medical SimMan or the METI ECS to over $200,000 for the METI HPS. Optional equipment available for these simulators can make the purchase costs even higher. In addition to the simulator, it is critical to create a learning environment that replicates real-world settings, complete with appropriate medical equipment. Halamek et al. (2000) stated, "The key to effective simulation-based training is achieving suspension of disbelief on the part of the subjects undergoing training, ie, subjects must be made to think and feel as though they are functioning within a real environment (para 15).” Creating this environment adds additional costs to setting up a simulation-based medical education program.

Statement of the Problem

Much has been reported on the use of high-fidelity manikin-based patient simulations in many types of healthcare provider education programs. However, very little research has been published on the impact of high-fidelity manikin-based patient simulations in American Heart Association Advanced Cardiovascular Life Support courses, despite this course being one of the more common medical certification programs in the United States.

Purpose of Study

The purpose of this study was to determine if the use of high-fidelity manikin-based patient simulators improves the educational outcomes of students as compared to the educational outcomes in students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support course.

Hypotheses

There were two directional hypotheses for this study:

H^1 Students who use high-fidelity manikin-based patient simulators will have better competence as demonstrated in post-intervention skills assessments graded by an expert rater compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

H^2 Students who use high-fidelity manikin-based patient simulators will have greater anticipated confidence in responding appropriately to real-world situations as demonstrated in self-administered post-intervention quantitative and qualitative survey assessment compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

Research Questions

In addition to the hypotheses being proposed, additional research questions were be asked. These questions were:

Q^1 Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of affect towards the course content as measured by the Affective Learning Scale instrument in an American Heart Association Advanced Cardiovascular Life Support program?

Q^2 Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of motivation towards the course content as measured by the Student Motivation Scale in an American Heart Association Advanced Cardiovascular Life Support program?

Definition of Terms

The literature on human patient simulation has attempted to define several of the terms used in this study. However, there is no general consensus on many of these terms - including a debate on whether the simulator is a *mannequin* or a *manikin* (Gaba, 2006). One key term that requires specific definition for this study is high-fidelity manikin-based patient simulator. The term fidelity has been problematic in its definition (Maran &

Glavin, 2003). As defined by Miller (1987), “The term ‘fidelity’ is used to designate how true to life the teaching/evaluating experience must be to accomplish its objectives (p. 36).” Using this definition, fidelity becomes a sliding scale in which given the objectives, a single piece of medical simulation equipment may be able to provide a “high-fidelity” experience for one objective but be “low-fidelity” for another objective. An example would be the insertion of an intravenous (IV) catheter. If the objective were to merely teach the psychomotor skills required for inserting the catheter, a relatively simple and low-tech IV access arm partial-task simulator would suffice and provide a comparatively high-fidelity experience. But if the objective were expanded to include communication with the patient, then the same device would suddenly become low-fidelity, as there is no feedback being delivered with IV catheter insertion and communication with the patient is not possible.

Beaubien and Baker (2004) noted that the term fidelity is frequently cited as a one-dimensional term that forces a static classification of simulation devices. Individuals with this perspective would have difficulty agreeing with the use of the terms as cited in the preceding paragraph.

Maran and Glavin (2003) offered this definition: “Fidelity is the extent to which the appearance and behaviour of the simulator/simulation match the appearance and behaviour of the simulated system (p. 23).” Expanding on this concept, Maran and Glavin further explained there is a difference between engineering fidelity and psychological fidelity:

> Engineering, or physical fidelity is the degree to which the training device replicates the physical characteristics of the real task…Of much greater

importance is the concept of psychological fidelity. This is the degree to which the skill or skills in the real task are captured in the simulated task. (p. 23)

Yaeger et al. (2004) broke fidelity down into three general classifications: low-medium- and high-fidelity. Their definitions of each stated:

- Low-fidelity simulators are focused on single skills and permit learners to practice in isolation.
- Medium-fidelity simulators provide a more realistic representation but lack sufficient cues for the learner to be fully immersed in the situation.
- High-fidelity simulators provide adequate cues to allow for full immersion and respond to treatment interventions.

Another component critical in high-fidelity manikin-based simulators is the ability to provide feedback (Bradley, 2006; Lane, Slavin, & Ziv, 2001). Feedback comes in two forms. First is the simulator's response to treatment or intervention by the learner. As described by Joyce, Weil, and Calhoun (2004), this is "self-generated feedback (p. 328)." High-fidelity simulators require the simulator to demonstrate appropriate responses to therapeutic interventions. This point of feedback is critical in determining the fidelity of a manikin-based simulation system. As Lane, Slavin, and Ziv (2001) noted, "an inherent feature of most advanced medical simulators is the ability to provide immediate feedback about clinical decision and quality of actions (p. 306)." For instance, if a medication is given to increase the heart rate, then the simulator should respond accordingly with a faster pulse. Conversely, if an intervention is provided that is not indicated and is potentially harmful, the simulator should respond with the physiological changes appropriate for this therapeutic misadventure.

A second form of feedback required in high-fidelity manikin-based patient simulators is the ability to provide objective feedback for participant review in the post-simulation setting. From the introduction of high-fidelity manikin-based patient simulators in the late 1960s, this feature has been key. Denson and Abrahamson (1969) highlighted this feature in their SimOne simulator:

> At the instructor's command, during or at the end of the training run, the computer will type out in detail a timed, chronological summary of all of the events of the exercise. This printout includes all of the student's manipulations of the simulator, the drugs given (their dosages and when they were given), and the occurrences of any other events. (p. 505)

The high-fidelity manikin-based patient simulators currently available all have proprietary software designed to log student actions and simulator responses for playback in the post-simulation debriefing. Instructors/Facilitators utilize this data to review the event with students as a means of encouraging student reflection on action and as a stimulus for students to consider how to change their actions to improve patient (simulator) response.

For the purposes of this study, the following definitions were used:

1. American Heart Association Advanced Cardiovascular Life Support (ACLS) program – An American Heart Association course designed to provide learners with knowledge and skills in adult Emergency Cardiovascular Care.
2. ACLS Mega Code Performance Score Sheet – Score sheet developed by the American Heart Association to test student skills performance at the completion of an Advanced Cardiovascular Life Support class.

3. Affect – A self-reported measure of a student's affective behaviors regarding resuscitation as measured by the Affective Learning Scale.

4. Affective Learning Scale – A self-administered affect instrument identified in Rubin, Palmgreen, and Sypher (1994).

5. Competence – Ability to perform task according to a performance criterion. In this study, the performance criterion is the ACLS Mega Code Performance Score Sheet.

6. Confidence – Self-reported measure of individual confidence in performing the task of rendering medical aid to a victim of cardiac arrest.

7. Educational Outcome – The combination of competence and confidence that reflects an individual student's ability in the subject area.

8. Expert Rater – ACLS Instructor who has been recognized by the American Heart Association with the status of ACLS Regional Faculty or Training Center Faculty.

9. Healthcare Provider – An individual who is employed or volunteers service as either a certified or licensed patient care provider.

10. High-fidelity manikin-based patient simulator – A full-bodied manikin that replicates human body anatomy and physiology relevant to cardiac arrest (including peri- and post-arrest conditions), is able to respond to treatment interventions relevant to cardiac arrest resuscitation management, and is able to supply objective data regarding student actions through debriefing software.

11. Low-fidelity manikin – A full-bodied manikin that replicates human anatomy, but does not have physiologic functions (including spontaneous breathing, palpable pulses, heart and lung sounds, and voice capabilities), does not have a physiologic

response to treatment interventions, and does not have a debriefing software system.

12. Motivation – A self-reported measure of state motivation as determined by the Student Motivation Scale.

13. Post-intervention skills assessment – Scoring instrument completed by expert raters and used to measure competence. In this study that instrument will be the ACLS Mega Code Performance Score Sheet.

14. Post-intervention quantitative and qualitative survey assessment – Self-administered questionnaire used to solicit information regarding students' perceived self-efficacy in performing resuscitation skills.

15. Resuscitation – The process of providing care to an individual patient who is either in cardiac arrest or is in a crisis situation that may quickly lead to cardiac arrest.

16. Student Motivation Scale – A self-administered motivation scoring instrument identified in Rubin, Palmgreen, and Sypher (1994)

17. Students – Senior-year nursing students from one of four nursing education programs located near research site.

Significance of the Study

Considering the high cost of high-fidelity manikin-based patient simulators compared to the more common manikins of lower fidelity, determining the impact of these devices on educational outcomes is critical in justifying their purchase and use in ACLS. Today's healthcare market is under very tight financial constraints. Other authors have noted the need to justify the use of these expensive resources in the most appropriate manner possible. Tsai, Harasym, Nijssen-Jordan, Jennett, and Powell (2003) stated:

> …a high-fidelity manikin-based simulation is expensive, as well as time and labour intensive. These factors may hinder many academic centers from adopting this technology into their educational activities. Justification about the value of use comparing high-fidelity simulation and traditional teaching strategies is necessary. (p. 72)

Kneebone (2005) concurred with this view, stating, “The relationship between simulator fidelity and educational outcomes is still open for discussion, however, and lower levels of fidelity may reduce technological limitations and cost without compromising outcomes (p. 551-552).” W. B. Murray and Schneider (1997) noted, “All levels of cognitive learning are not equally appropriate for full-environment simulation (para 5).” They continued, stating that lower levels of cognitive learning may be better presented in traditional classroom teaching. Higher function levels such as analysis may be better suited to simulation.

With reduced revenues from major payors, particularly governmental payors such as Medicare and Medicaid and the potential for more cuts in the future, many healthcare systems are forced to reduce expenses (Carey, 2006; Dickler & Shaw, 2000; Lederman, 2005; Phillips Jr. et al., 2004). Education departments are often among the first departments adversely effected (Hotvedt & Laskowski, 2002). Health professions education organizations, including higher education institutions and teaching hospitals, are also under financial constraints. One study mentioned funding cuts that directly impacted its simulation program (Feingold, Calaluce, & Kallen, 2004). George Rupp, then president of Columbia University, noted the following in regards to the operation of Columbia-Presbyterian Medical Center:

> The major sources of funds for academic medicine - government research grants, revenues generated from the care of patients by the medical faculty, and direct appropriations for the support of hospitals - are facing simultaneous threats. Congress is under pressure to reduce health care spending for the elderly and the poor. The funds that support the training of new doctors are specifically targeted for cuts (Rupp, 1996, para 4).

Phillips et al. (2004) summed it up by stating, “Teaching hospitals of all sorts are in dire straits (p. 75).” Phillips continued, asking, “How will teaching hospitals cope financially with patient safety mandates, increasing pressure to improve resident work environments and hours, rising malpractice premiums, and other rising health care costs (p. 77)?” Given the limited financial resources for these organizations, it is imperative that available money be budgeted appropriately and resources used to its best advantage.

An additional area of significance in this study is the ability to improve the training of healthcare providers. Shortcomings in the training of healthcare providers have been noted, especially in physician education. Issenberg, McGaghie Petrusa, Lee, Gordon, and Scalese (2005) noted:

> Changes in the delivery of healthcare trigger major shifts in medical education methods. For instance, in the United States, the pressures of managed care are shaping the form of and frequency of hospitalizations, resulting in higher percentages of acutely ill patients and shorter inpatient stays. This results in less opportunity for medical learners to assess patients with a wide variety of diseases

> and physical findings. Despite increased cost-efficiency in outpatient care, reductions in physician reimbursement and shrinking financial resources constrain the educational time that physicians in training receive in this environment. Consequently, physicians at all educational levels find it increasingly difficult to keep abreast of skills and topics that frequently appear in practice.
>
> These problems have a direct effect on clinical training…The result is a decline in the quality of healthcare providers' bedside skills and a reduction in the ability to provide high quality and cost-effective medical care. (p. 12)

In ACLS level care, having the most well prepared healthcare providers is essential, especially for physicians. This point is critical as the team leader in the in-hospital cardiac arrest is most frequently a physician and in many teaching hospitals is a resident physician. To improve cardiac arrest outcomes, it is vital to ensure that healthcare providers have the best possible resources available for their education and training.

This study will provide valuable information that will aid healthcare education curriculum developers and planners with the most efficient use of their resources. While several studies have demonstrated the efficacy of high-fidelity manikin-based patient simulators in a variety of healthcare education programs and settings, there is very little information on the value of the devices in a comparatively high volume program such as ACLS. Additional information on the efficacy of high-fidelity manikin-based patient simulators in this application is needed. If the hypotheses are supported, high-fidelity manikin-based patient simulators will be shown to be an effective resource to improve educational outcomes in ACLS. If the hypotheses are not supported, then the limited resource of high-fidelity manikin-based patient simulators may be better utilized in other programs where research has shown greater efficacy.

Salas and Burke (2002) noted that simulation is effective when the simulation fidelity is matched by training requirements. As they state, “When using simulations for training purposes, it is often assumed that more is better; that is not true...The level of simulation fidelity needed should be driven by the cognitive and behavioral requirements of the task and the level needed to support learning (p. 120).” With that in mind, effective ACLS training should be conducted with the most appropriate technology, not just the most advanced technology.

As previously stated, no study on the efficacy of high-fidelity manikin-based patient simulation as compared to traditional training with low-fidelity manikins in the context of an actual ACLS course has been published. This study will attempt to fill that gap in the research literature. On the larger scale of patient simulation in all areas, there is a continuing need for additional research to demonstrate efficacy. As one recent review noted:

> …at the present time the quantity and quality of research in this area of medical education is limited. Such research is needed to enable educators to justify the cost and effort involved in simulation and to confirm the benefit of this mode of learning in terms of the outcomes achieved through this process. (Bradley, 2006, p. 254)

Additionally, very few studies have tied the use of high-fidelity manikin-based patient simulators to educational theory. With the majority of studies being published in the medical literature, the outcomes focused almost exclusively on reporting quantitative or qualitative results, providing very little explanation of why one approach worked or did not work based on curriculum theory. This paper fully examined the education and curriculum theory applications to using high-fidelity patient simulators.

Limitations of the Study

Limitations for this study included:

1. This study was located at one American Heart Association Training Center. There are over 3,600 AHA Training Centers in the United States. While the AHA ECC programs, including ACLS, are tightly regulated to ensure consistency, there is a limitation to generalizing this study to the greater population of ACLS courses nationwide.
2. This study was limited to only one type of professional healthcare provider (senior nursing students) with limited healthcare experience. Generalizability to other healthcare professions and to healthcare providers with varying levels of experience will be limited.

CHAPTER TWO: REVIEW OF THE RELEVANT LITERATURE

ACLS as an Educational Intervention

The American Heart Association Advanced Cardiovascular Life Support program has been well tested and reviewed in the literature. As the principle intervention in this study, it is worth examining the efficacy of ACLS as an educational intervention. The need for Advanced Cardiovascular Life Support training has been well documented by several authors including Birnbaum, Kuska, Stone, and Robinson (1994).

Birnbaum, Kuska, Stone, and Robinson (1994) conducted a descriptive study of 461 healthcare providers including physicians, registered nurses, licensed practical nurses, pharmacists, emergency medical technicians, and nursing assistants at 12 rural hospitals. Their findings represented a baseline of ACLS level knowledge that indicated there were serious deficits in knowledge regarding electrocardiograms, pharmacology, and airway management. Their study compared their data set with another data set from Seidelin, McMurray, Stolarek, and Robertson (1989) that reviewed the basic and advanced cardiopulmonary resuscitation skills of 105 United Kingdom nurses staffing urban tertiary care hospitals. They determined the results of their study and the Seidelin, McMurray, Stolarek, and Robertson study were not significantly different. Several additional studies documented in this literature review also reflect poor baseline knowledge of healthcare providers concerning management of cardiopulmonary emergencies.

ACLS Outcomes

The American Heart Association Advanced Cardiovascular Life Support course has become a standard course of training for many healthcare providers and is often a required part of a healthcare practitioner's medical education (Makker, Gray-Siracusa, & Evers, 1995; Marchette et al., 1985; O'Steen, Kee, & Minick, 1996). Householder-Hughes (2002) commented the course "has been the recognized source for resuscitation education since its inception (p. 9)." Several studies have shown that ACLS and its pediatric counterpart course, Pediatric Advanced Life Support, have been effective. These studies can be broken into two general groups. First are studies that examined the effect of the course on learning as judged by posttest evaluations. Second are studies that examine the effect of the course on actual patient survival.

In the first category of studies – those that examine the effect of the course on learning – several studies were identified as relevant (Boonmak, Boonmak, Srichaipanha, & Poomsawat, 2004; Marchette et al., 1985; Quan, Shugerman, Kunkel, & Brownlee, 2001; Waisman, Amir, & Mimouni, 2002)

Marchette et al. (1985) conducted a quasi-experimental study with no randomization and a pretest/posttest design. Their study included 76 healthcare providers assigned to either a control group that received no training or an intervention group that completed an ACLS course. Their results showed that the course was effective in teaching the skills of cardiac arrest resuscitation when using the Mega Code testing format as an evaluation instrument. Of the 37 subjects enrolled in the intervention, successful completion of the Mega Code testing increased from four in the pretest to 27 in the posttest while the control group showed no change in performance level.

Boonmak, Boonmak, Srichaipanha, and Poomsawat (2004) enrolled 39 nurse anesthetists in a one-group pretest-posttest design that also included a delayed posttest three months after the intervention. Their intervention was an abbreviated ACLS course that was shorter than most ACLS courses. Their testing format included both a knowledge test and a skills test. The authors found their intervention significantly increased both ACLS knowledge and skills in the immediate posttest. They found that knowledge deteriorated to the pretest level at three months. However, their findings did indicate skill level remained high with the three-month posttest scores not being significantly different than the immediate posttest scores of skills performance.

Quan, Shgerman, Kunkel, and Brownlee (2001) conducted a one-group pretest-posttest design using 39 pediatric post graduate year 1 resident physicians using the Pediatric Advanced Life Support course as the intervention. PALS is very similar to ACLS in course design, content, and scope. Their area of focus was on skill acquisition. They used a set of expert raters to score skill proficiency in four specific areas (bag/mask ventilations, endotracheal intubation, intraosseous access, and defibrillation) before and after the intervention. They found the course intervention significantly improved subject skill performance. They also conducted interobserver reliability tests and found a very high level of interobserver reliability, with correlation coefficients ranging from .65 to .99.

Waisman, Amir, and Mimnouni (2002) conducted a one-group pretest-posttest design using 370 subjects (physicians, nurses, and paramedics) who completed a PALS program (19 programs were conducted). Differing from Quan, Shgerman, Kunkel, and Brownlee (2001), Waisman, Amir, and Mimnouni focused on knowledge acquisition rather than skills. Their findings showed significance in that 83.5% of the posttest subjects passed the written evaluation as opposed to 61.9% who passed the pretest ($p < 0.0001$).

In the second category of studies – those that examined the effect of the course on patient survival – several studies were identified as relevant (Birnbaum et al., 1994; Dane, Russell-Lindgren, Parish, Durham, & Brown, 2000; Lowenstein, Sabyan, Lassen, & Kern, 1986; Makker, Gray-Siracusa, & Evers, 1995; A. B. Sanders et al., 1994; Schneider, Mauer, Diehl, Eberle, & Dick, 1995)

Birnbaum et al. (1994) conducted a case-controlled retrospective study of 869 consecutive patients admitted with ischemic heart disease at seven rural hospitals. Their intervention was a multi-disciplinary ACLS class (including physicians, registered nurses, licensed practical nurses, and respiratory therapists). Patient data were examined pre- and post-intervention in an effort to determine patient outcomes. In examining patient outcomes, they found overall patient mortality decreased from 17.4% to 13.1% and was significant at the $p = .05$ level. Their findings showed that pretest/posttest comparisons of each of the groups of healthcare providers increased significantly (p =/< .05 in all cases) with the intervention, although there was some variation on individual areas of knowledge dependant on healthcare provider type. The increase in subject knowledge manifested itself in several ways after the intervention. These included:

1. Changes in hospital policies and procedures
2. Increased use of arterial blood gases
3. Better team conduct
4. Better team communications
5. New equipment purchases
6. Improved emergency response cart inventory
7. More requests for continuing education

8. More request for American Heart Association certification

These changes that were brought about by having subjects take the ACLS course may be viewed by some as confounding variables in the improved outcome of patients. Nonetheless, these changes were caused by the ACLS course intervention. However, there is one complicating factor of note. The intervention ACLS course used in this study did represent overtraining, as it was 39 hours in duration versus the more usual 16 hours.

Dane, Russell-Lindgren, Parish, Durham, and Brown (2000) conducted a cohort case comparison study of 120 cardiopulmonary emergency events and examined the responding nurses' ACLS provider status. They examined several variables that affected survival and found that only two variables showed significance: severity of cardiac rhythm and ACLS training. Their findings showed that survival was almost four times higher when the responding nurse had received ACLS training. Specifically, 37.5% of cardiac arrest victims who had an ACLS-trained responding nurse survived compared with 10.3% of cardiac arrest victims who had a responding nurse with no ACLS training.

Lowenstein, Sabyan, Lassen, and Kern (1986) conducted a retrospective chart review looking at two six-month periods, one before initiation of a required ACLS course for house physicians and one after the initiation of the required ACLS course. There were 90 cardiac arrest events during the study, with 37 occurring before the ACLS implementation and 53 afterwards. Short-term survival (return of spontaneous circulation) increased from 32% to 60% and was significant at $p = .009$. Survival to discharge also saw a near doubling with survival to discharge increasing from 13% to 23%. However, do to the fairly low total number of survivors, statistical power was not present to indicate significance.

A. B. Sanders et al. (1994) conducted a retrospective chart review covering 13 months prior to the introduction of an ACLS training program and the 13 months after the implementation of the ACLS program. During the time frame, 64 cardiac arrest cases were reviewed (29 pre-ACLS and 35 post-ACLS). Their findings showed a significant increase in event survival for one subset of cardiac arrest victims – those whose initial rhythm was ventricular fibrillation (0 survival for 9 events in the pre-ACLS period and 6 survival for 15 events in the post-ACLS period, $p < .05$). However, overall survival for all cardiac arrest rhythms did not show significance.

Makker, Gray-Siracusa, and Evers (1995) conducted a prospective consecutive patient case study that had multiple outcomes. One outcome was comparing outcomes of cardiac arrests between ACLS certified physicians and non-ACLS certified physicians. During the study year, 225 patients experienced cardiac arrest and required resuscitation. One finding of note was that relatively inexperienced medical residents who were ACLS certified had a slightly better, but not significant, cardiac arrest patient survival rate when compared to experienced cardiologists who were not ACLS certified (48.7% vs. 46.7%).

Camp, Parish, and Andrews (1997) conducted a multiyear retrospective chart review examining a four-year period prior to the initiation of an ACLS course program and a three-year period after implementation of the ACLS course program in a rural community hospital. While their data showed a relatively equal number of survivors between the two time periods (36% vs. 29% respectively), the overall number of resuscitation events rose dramatically in the latter time period as resuscitation efforts were expanded from the Intensive Care Unit to all parts of the hospital. This resulted in a significantly higher number of cardiac arrest victims surviving. In their conclusion, the authors felt that despite relatively equal survival rates, the increased resuscitation knowledge across the organization lead to a greater number of resuscitation cases being initiated resulted in a greater number of survivors, thus justifying the implementation of the ACLS course.

Makker, Gray-Siracusa, and Evans (1995) conducted a prospective consecutive patient case study that evaluated errors in actual resuscitations as a means of determining retention of ACLS knowledge. During the study year, 225 patients experienced cardiac arrest and required resuscitation. While the majority of cardiac arrest events were managed by ACLS certified healthcare providers, a portion of the total number of cardiac arrests were managed by non-ACLS-certified providers. Errors were classified into two groups: rhythm identification errors and treatment errors. Findings showed a 12% overall error rate, with 3.6% being rhythm identification errors and 9.8% being treatment errors (there was a small overlap that produced both rhythm identification and treatment errors). The error rate for ACLS certified providers was 10.6% while the error rate for non-ACLS-certified providers was 17.7%.

Studies such as Birnbaum et al. (1994), Camp, Parish, and Andrews (1997) Dane, Russell-Lindgren, Parishm Durham, and Brown (2000), Lowenstein, Sabyan, Lassen, and Kern (1986), Makker, Gray-Siracusa and Evers (1995), and A. B. Sander et al. (1994) represent particularly important results as their outcomes represented the highest level of evaluation of program effectiveness. Kirkpatrick (1998), in his update of his 1959 article introducing the four-level model of evaluation, noted that level-four represents the highest level of education program effectiveness – results. As he stated, “This is a measure of the final results that occur due to training, including…improved quality (p.

5).” In cardiac arrest resuscitation, the final result is patient survival. Kirkpatrick continued, “Evaluation becomes more difficult, complicated, and expensive as it progresses from level 1 to level 4 – and more important and meaningful (p. 5).”

ACLS Knowledge and Skill Retention

One problem with ACLS education identified by several authors is one of retention (Boonmak, Boonmak, Srichaipanha, & Poomsawat, 2004; Kaye, Mancini, & Rallis, 1987; Lin, Chi, Chen, & Wang, 2000; Nadel et al., 2000; O'Steen, Kee, & Minick, 1996; Stross, 1983; Wolfram, Warren, Doyle, Kerns, & Frye, 2003).

Stross (1983) conducted an experimental study with a control group and intervention groups that received reinforcement after their ACLS course. His findings showed that knowledge and skill retention one year after the course was significantly lower than after immediate completion of the course for the control group. In the one-year posttest that involved a mock-cardiac arrest situation, only 52% of the control group subjects were able to adequately treat the case. Subjects in the two intervention groups supplied adequate treatment in 75% and 82% of the cases, both showing significance at the $p = 0.05$ level when compared to the control group. The study did not report if the intervention group’s one-year posttest was significant from their immediate posttest.

O’Steen, Kee, and Minick (1996) conducted a correlational study to examine the amount of ACLS knowledge retained over time using both the ACLS written evaluation and a Mega Code scenario as testing instruments. Their results showed significant decreases in knowledge and skill performance within the first 12 months after successful completion of the ACLS course. They also found that this deterioration tended to stabilize at the 12-month time frame and not significantly decrease over the next 12 months. An additional finding in this study was that years of advanced life support experience and the number of ACLS courses taken over those years were predictive variables to ACLS written evaluation success. Predictive variables for successful completion of the skills evaluation included years employed in nursing, perceived ability to recall ACLS information, and place of work (cardiac intensive care unit or emergency department).

Kaye, Mancini, and Rallis (1987) conducted a series of evaluations before, immediately after, and two to four months after a specially designed ACLS refresher course intended for healthcare providers who had already taken a complete ACLS course previously. The testing format consisted of individual subjects leading a Mega Code scenario and being scored on an objective-based checklist. Their study found two interesting results. First was that the pretest showed deficiencies in some areas, despite all subjects having taken an ACLS previously. Second, retesting two to four months after the refresher course showed skill level as still relatively high. Of the seven areas tested for significance comparing the immediate posttest with the delayed posttest, only two of these areas showed skill performance had degraded to the point of reaching significance. When comparing the pretest to the immediate posttest, three of the seven areas reach levels of significance.

Nadel et al. (2000) examined pediatric resident physicians' Pediatric Advanced Life Support knowledge and skill level in a one-shot case study. They found that cognitive knowledge remained high with a mean score of 93.2%. However, a 12-item short answer scenario-based written simulation showed only 60% successful completion. On the skill evaluations, deficits were seen in several areas and none of the subjects were able to successfully perform all four skills being evaluated (ancillary airway maneuvers, endotracheal intubation, Seldinger vascular access procedure, and intraosseous placement). Nadel and colleagues did not conduct any correlation studies comparing time of last PALS program to time of the reevaluation.

Birnbaum et al. (1994) showed that retention remained high even at one to two years post intervention. As they noted, “there was no significant deterioration in the knowledge base or integrative skills of the participants who had taken the ACLS course (p. 745).” They did find some skill deterioration that was evident at six months post intervention. Once this skill deterioration was noted, it remained constant over the two-year interval. They did not note if this deterioration was significant, only stating that “some deterioration” was seen.

Kaye et al. (1985) noted that several factors influence survival from cardiac arrest including the quality of basic life support and ACLS level care. As they stated, there are problems in the literature regarding consistent definitions and evaluation methods, a uniformly applied curriculum, clear objectives, and the documentation of cardiac arrest events. After reviewing many of the studies included in this literature review, in the 20 years since the publication of their articles many of these same issues remain today.

Despite problems associated with retention of knowledge and skills as well as the issues raised by Kaye et al. (1985), the American Heart Association Advanced Cardiovascular Life Support course has been shown to be an effective education intervention for teaching Emergency Cardiovascular Care when comparing results on immediate learning and – more importantly – on the survival of patients with cardiopulmonary emergencies. This has been demonstrated through several high-quality reports that utilized randomized experimental designs or cohort case studies. As Lowenstein, Sabyan, Lassen, and Kern (1986) stated in their conclusion, "…survival after in-hospital cardiac arrest is significantly improved if the physicians who staff the Code teams are trained in ACLS. The ACLS course is an easily-implemented, salient, and effective medical education program, which decreases mortality (p. 518)." The literature presents evidence that expands on this conclusion to include other members of the cardiac arrest response team, including nurses.

What is simulation?

There have been many definitions made as to what simulation is in education. Some of these definitions refer to the "simulator" while others refer to the "simulation."

- "A simulator is a training device that closely represents reality but in which the complexity of events can be controlled (Joyce, Weil, & Calhoun, 2004, p. 327)."
- "Simulation is a training and feedback method in which learners practice tasks and processes in lifelike circumstances using models or virtual reality, with feedback from observers, peers, actor-patients, and video cameras to assist improvement in skills (Eder-Van Hook, 2004, p. 4)."
- "Simulation is a generic term that refers to the artificial representation of a real-world process to achieve educational goals via experiential learning (Flanagan, Nestel, & Joseph, 2004, p. 57)."
- "Simulation is a technique…to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner (Gaba, 2004b, p. i2)."

- “Simulation is the artificial representation of a phenomenon or activity (Larew, Lessans, Spunt, Foster, & Covington, 2006, p. 17).”
- “Simulations are created experiences that mimic processes or conditions that cannot or should not be experienced firsthand by a student because of the student’s inexperience or the risk to the patient (Morton, 1997, p. 66).”
- Simulation “refers to an activity that is designed to help participants acquire insight into the complex relationships and interconnected structures within a particular context. It is a way of preparing for (or reviewing) action in the real world (Leigh & Spindler, 2004, p. 54).”

When examining the use of high-fidelity manikin-based patient simulators in health professions education, it is critical to not confuse the simulator with the simulation. As Gaba (2004b) described, “Simulation is a technique – not a technology (i2).” The devices are only part of the simulation. Dutta, Gaba, and Krummel (2006) observed a discrepancy in the research literature, stating, “A fundamental problem in determining the effectiveness of surgical simulation has been an inability to frame the correct research question. Are the authors assessing *simulation* or *simulators* (p. 301)?” Hammond (2004) recounted Gagne’s 1962 work examining military simulation:

> He [Gagne] observed that is was not necessarily the device that was being simulated, but the operations or tasks associated with it. These included troubleshooting (ie, diagnosis), procedures (ie, therapies), and communication of information (ie, team leadership). He concluded that the educational use of simulators should be at advanced stages and may include performance assessment. (p. 325)

Simulation has many applications. While at first glance, the teaching of psychomotor skills seems an obvious use for simulation; there are other areas where simulation can be effectively utilized. Rauen (2004) listed several areas in addition to psychomotor skill training where simulation has been utilized. Her list included teaching theory, patient assessment, use of technology, and pharmacology. She stated, "The emphasis in simulation is often on the application and integration of knowledge, skills, and critical thinking (para 3)."

As noted in Chapter 1, there is considerable debate about what constitutes a high-fidelity simulation. Too often, the definition is applied to the technology (Beaubien & Baker, 2004). There are several types of fidelity to be considered when evaluating the overall fidelity of the scenario. While developed for aviation simulation, the concepts suggested by Rehmann, Mitman, and Reynolds (1995) list several types of fidelity to consider that have implications in patient simulation. These include: "equipment fidelity, environmental fidelity, psychological fidelity, task fidelity, physical fidelity, and functional fidelity (p. vii)."

Joyce, Weil, and Calhoun (2004) identified 10 applications for simulations in education. While their list was for education in general, there are direct examples of each application in healthcare provider education.

1. Competition – Simulators have been used frequently in healthcare provider education as a means of assessment, which could be considered a form of competition.
2. Cooperation – Teamwork is a critical skill that is frequently featured in healthcare simulation scenarios.

3. Empathy – Realistic simulators that have the ability to speak can allow learners to demonstrate empathy for the simulated patient. Additionally, when conducting multidisciplinary simulation sessions, empathy can be generated for the roles of other team members.
4. The social system – Team skills in a multidisciplinary team often involve complex social interactions between team members of varying levels of authority and experience.
5. Concepts – Demonstration of concepts such assessing the simulator to find a diagnosis is a common simulator use.
6. Skills – Many simulation education sessions involve the application of psychomotor skills, such as endotracheal intubation, to be performed.
7. Efficacy – During the simulation, learners have the opportunity to see the effect of their actions and determine if their action achieves the desired effect.
8. Paying the Penalty – Since the simulation will allow for mistakes, consequences of those mistakes can be seen and discussed.
9. The role of chance – While one advantage of simulation is standardization, there is still the element of chance being introduced as an unintended consequence.
10. The ability to think critically – Through the process of reflection (either reflection in action while the simulation scenario is progressing or reflection on action after the simulation is complete), learners develop the skills needed to critically analyze their own actions and develop new strategies.

Gaba (2004b) generated a list of 11 dimensions to be considered in healthcare provider education utilizing patient simulation:

1. The purpose and aims of the simulation – Simulation may have one of several goals that include: education, training, performance assessment, clinical practice rehearsals, testing organizational practices, and investigating human factors performance.
2. The unit of participation in simulation – The simulation may be targeted at a single learner or it may be focused on an entire team. With the single learner the goals of the simulation will be focused on that individual's knowledge and skills. With the team, the focus may shift to coordination of action, teamwork, and communications.
3. The experience level of simulation participants – Simulation has shown its utility in teaching a wide range of clinical healthcare providers – from the novice through the expert. The difficulty of the simulation scenario may need to be adjusted depending on the level of clinical experience.
4. The health care domain in which simulation is applied – Simulations are most practical in medical domains where there is some element of psychomotor skill application or therapeutic intervention. Even in domains where psychomotor skills are not a major part of the skill set required for success, there may be simulation application, such as in communications skills or team management.
5. The health care disciplines of personnel participating in the simulation – Simulations may have a very diverse audience – ranging from high-level

clinical providers such as physicians and nurses to lower level providers such as technologists or aides, and may even involve non-clinical personnel such as admitting personnel or administrators.

6. The type of knowledge, skill, attitudes, or behavior addressed in simulation – Depending on what is to be addressed, different types of simulations may be better at addressing what is to be learned. There may also be the need to integrate multiple areas – such as a combination of knowledge and skill – within one simulation to make the experience meaningful.
7. The age of the patient being simulated – While healthcare providers may have a need to provide care from “cradle to grave,” not all potential patient age groups may be appropriately represented by the simulation technology.
8. The technology applicable or required for simulations – Not all simulations require technology. Some situations may be simulated by simple verbal simulations, or, as Gaba defined, asking “what if?” questions. However, some goals such as skills or teamwork integration may require a more hands-on learning environment that will utilize some form of simulation technology.
9. The site of simulation participation – Some simulations may work well being conducted in a simulation learning laboratory or center. Other simulations may require on site, or *in situ*, simulation. While the dedicated simulation center may work well for many simulations, if one of the goals of the simulations is to test processes, it may be better performed in situ in order to test those processes where they will be used.

10. The extent of direct participation in simulation – All learners may not need to directly participate in the simulation in order to learn from it. Observation and participation in the debriefing may be adequate for some situations.
11. The feedback method accompanying simulation – While experience in itself may be valuable, the more substantial learning in simulation comes from feedback. Some simulators – particularly computer-based simulators – provide their own objective feedback information. Other simulators require the instructor or facilitator to provide feedback in the form of a debriefing session with the learner(s), often using the objective feedback information generated by the simulator. This debriefing may be aided by audio/video recordings or objective data recorded by the simulator.

Why Use Simulators?

Patient simulation of all types, including high-fidelity manikin-based patient simulation, is becoming more prevalent in many aspects and levels of healthcare provider education (Good, 2003; J. A. Gordon, Oriol, & Cooper, 2004; Issenberg, McGaghie et al., 1999). The reasons behind the increased use for patient simulation are many and include: the growth of medical knowledge, changes in medical education, patient safety, improved realism of simulation devices, availability of patients, new demands on student availability, and the ability of simulation to provide standardization and replication. For new healthcare providers it is also important to consider the changing student profile. Mallow and Gilje (1999) point out that today's students are more comfortable with technology.

Issenberg, McGaghie et al. (1999) pointed out several advantages to patient simulators:

> Unlike patients, simulators do not become embarrassed or stressed; have predictable behavior; are available at any time to fit the curriculum needs; can be programmed to simulate selected findings, conditions, situations, and complications; allow standardized experience for all trainees; can be used repeatedly with fidelity and reproducibility; and can be used to train both for procedures and difficult management situations. (p. 862)

Kneebone (2003) summarized several challenges for learning in healthcare provider students:

> How is it possible to safely carry out the sustained, deliberate, goal-directed practice that expertise requires? How is it possible to integrate technical skill with the knowledge upon which it depends? And how can these elements be combined to ensure the development of professionalism? Simulation…presents an attractive solution, at least to some of these issues. It offers a safe, non-clinical environment designed to meet the educational needs of a range of learners. (p. 269)

In an earlier publication, Kneebone stated, “This shift in emphasis from the clinical needs of the patient to the educational needs of the learner is having a profound effect on medical education generally, and on skills training in particular (Kneebone, 1999, p. 571).”

While simulation does represent a viable alternative to healthcare provider education, it should be only considered an adjunct to the curriculum and never as a complete replacement for the patient (Gaba, 2004b). Ewy, et al (1987) commented on simulation in cardiology education stating, “Patient-centered instruction remains the most important part of the curriculum…While the simulator should not replace the patient as a focus for teaching…patient centered instruction can be enhanced by use of this simulator (p. 743).” Kneebone (1999) commented, “Any simulation in medical training, however, must be seen as a prelude to doing the real thing on a real patient, never as an end to itself (p. 571).” While not referring to medical simulation, Elgood (1990) made these comments regarding where simulation fit into a continuum of learning, “simulation…is intended as an intermediate stage between theoretical instruction (which has obvious limitations) and the real thing (which is too often costly or too dangerous to be attempted) (p. 51).” Flanagan, Nestel, and Joseph (2004) also noted this distinction, but added that an effective curriculum coupled with “skilled and dedicated teachers (p. 57)” was essential.

Growth of medical knowledge

Medical knowledge is always growing. New medical tests, new medications, new technologies all bring about new understandings and knowledge. However, the healthcare provider curriculum is of finite length. Innovation in the curriculum is required in order prepare the next generation of healthcare providers. Issenberg, Gordon, Gordon, Stafford, and Hart (2001) made the following comments:

> In the past century, there has been an exponential growth in our knowledge of the human body, its structure, its functions, what can go wrong with it and why…Over the past few decades, medical educators have been quick to embrace new technologies and pedagogical approaches…in an effort to help students deal with the problem of the growing information overload. Medical knowledge,

> however, has advanced more rapidly than medical education…Simulation technologies are available today that have a positive impact on the acquisition and retention of clinical skills. (p. 16)

Alverson et al. (2005) provided additional comments, stating, "The vast amount of existing and emerging new knowledge in the health related sciences create new challenges in medical education. Furthermore, there are several medical science concepts that are difficult for learners to comprehend and educators to teach (p. 20)." They continued:

> Developing methods to determine adequate acquisition, retention, and competence in the application of these concepts and knowledge, as well as attainment of appropriate clinical skills, continues to be a major endeavor in medicine as efforts to decrease medical errors and improve quality of care have reached high levels of public interest. (p. 20)

Changes in Medical Education

Medicine has typically been taught using a lecture/apprenticeship model (McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005) that is reliant upon observation and repetition (Eder-Van Hook, 2004). As Halamek et al. (2000) stated the traditional model of medical education has three components: the learner performs a reading of the literature, the learner observes others with greater experience, and then the learner develops hands-on experience. This is the traditional medical model of education that has been in use for over 2,000 years (*Current state report on patient simulation in Canada*, 2005). Halamek et al. (2000) identified several problems with the current medical education model:

- While valuable, reading of the literature does not produce competency. More active than passive participation in the learning experience is required.
- Learners may have difficulty determining if their model for observation as a good model or a poor model. Just because the model may be senior, he or she still may not be competent and therefore the learners may observe poor skills as their basis for emulation.
- The variability of experiences in the apprenticeship model is high, meaning learners' experiences will not be equal.
- Many training environments do not fully represent the complexity of the real world resulting in an inability of the learners to adequately practice their decision-making skills in a contextual environment.

Yaeger et al (2004) reinforced these points stating that medical and nursing education rely on two fatally flawed assumptions:

- Assumption 1: All clinical role models are effective and skilled, and all behaviors demonstrated by these role models are worthy of replication.
- Assumption 2: The conclusion of the training period implies that a trainee is competent in all the skills necessary for successful clinical practice. (p. 326)

Yaeger et al. also commented that in the apprenticeship model there is a need for a preceptor. This preceptor may not have the necessary skills to be an effective educator.

Speaking of the traditional model, Issenberg, Gordon, Gordon, Stafford, and Hart (2001) observed, "This process is inefficient and inevitably leads to considerable anxiety on the part of the learner, the mentor, and at times the patient (p 19)." McMahon, Monaghan, Falchuk, Gordon, and Alexander (2005) stated this model "is inefficient in promoting the highest level of learned knowledge, as reflection and metacognition analysis occur independently, often without guidance and only after extended periods of time when students are able to piece together isolated experiences (p. 84-85)."

Traditionally, this format is often referred to as the "See one, do, one, teach one" model of medical learning (Dunn, 2004; Eder-Van Hook, 2004; Gorman, Meier, & Krummel, 2000; Wayne et al., 2006; Yaeger et al., 2004). Referring to the "See one, do, one, teach one" model, Vozenilek, Huff, Reznek, and Gordon (2004) commented:

> Medical educators are under considerable societal pressure and budgetary constraints to enhance the quality of medical education and the safety of medical care. The concept of "learning by doing" has become less acceptable, particularly when invasive procedures and high-risk cases are required…Despite the best efforts of educators, some procedures are so rare in clinical practice that they are difficult for trainees to "see and do," let alone teach. (p. 1149)

In their conclusion, they rephrased the traditional model, saying, "see one, simulate many, do one competently, and teach everyone (p. 1153)."

The whole of medical education is in the midst of reform with wide-spread calls for changes (Bradley & Postlethwaite, 2003b; Issenberg, Pringle, Harden, Khogali, & Gordon, 2003; S. MacDonald, 1994; A. K. Wong, 2004; Ziv, Wolpe, Small, & Glick, 2003). A. K. Wong (2004) noted the change in medical education, stating:

> The landscape of medical education is changing dramatically, shifting from what Carraccio et al. has termed a process and structure-based curriculum to what is known as an "outcome" or competency-based curriculum." The former curriculum determines learning on the basis of exposure to specified content over

a period of time, whereas the latter determines it on the basis of attainment of preset objectives or competencies. (p. 455-456)

Lane, Slavin, and Ziv (2001) reported on several studies that indicated poor outcomes for medical school graduates, stating that reform was required “in part because physicians were graduating from educational programs without adequate skills (p. 308).” As Greenburg, Loyd, and Wesley (2002) noted, “The changing health care environment, adult learning theory, and an emphasis on assessment and accountability has focused attention on teaching and testing clinical knowledge, attitudes, and skills (p. 1109).” Bradley (2006) cited three reasons behind the recent drive for patient simulation. First was the resuscitation education movement started by Laerdal and others in the early 1960s. Second was the development of anesthesia patient simulators starting with SimOne in the late 1960s. Third was the beginning and ongoing reform of medical education as a whole. Within reform he cited several areas where change has been evident:

- The need to respond to the information overload so that basic clinical and communication skills are properly developed.
- Increased emphasis on the development of a more educationally sound curriculum in the postgraduate training of physicians.
- The recognized need for improvements in continuing medical education.
- Increased efforts at revalidating provider competence.

He stated that simulation, particular high-fidelity simulation, is positioned to be an important part of this reform. More so, he sees simulation as “an essential element of an ethically cognizant education (p. 40).”

Looking specifically at the clinical side of medical education in critical care medicine, Grevnvik, Schaefer, DeVita, and Rogers (2004) stated three major changes in medical teaching have occurred in recent years. These changes included increased emphasis on evidenced-based medicine, higher prominence for patient safety in clinical teaching, and the evolution of patient simulation. On this last point, they noted that during the 10-year period from 1994 through 2004, the number of patient simulation centers went from "very few full-scale simulators in the world… [to] more than 1000 simulation centers (p. 234)."

Bradley and Postlethwaite (2003a) noted the problems with the current system of medical education, stating:

> Deficiencies in undergraduate programmes and a reliance on serendipity have been recognized as leading to inadequacy in the skills performance of students. These deficiencies often then result in junior doctors being required to perform skills for which they have not been prepared and as a result they perform suboptimally…It has been noted that the clinical experience of students is changing and that opportunities for them to acquire skills is reducing. (p. 6)

Patient Safety

An overriding theme in many discussions of high-fidelity manikin-based simulation is the concept of patient safety. In the education of healthcare providers, there are sometimes conflicting goals. As Friedrich (2002) commented in quoting Atul Gawande, "medicine has long faced a conflict between 'the imperative to give patients the best possible care and the needs to provide novices with experiences' (p. 2808)." When examining the broader topic of medical simulation in general, the concept of patient safety is a frequently mentioned theme (Abrahamson & Denson, 1969; Blum et al., 2004; Bradley, 2006; Cleave-Hogg & Morgan, 2002; J. B. Cooper, 2004; Deering, Brown, Hodor, & Satin, 2006; DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Flanagan, Nestel, & Joseph, 2004; Fried et al., 2004; Glavin & Maran, 2003; J. A. Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Grenvik, Schaefer, DeVita, & Rogers, 2004; Hamilton et al., 2001; Hammond, 2004; Haskvitz & Koop, 2004; Kneebone et al., 2005; Leitch, Moses, & Magee, 2002; H. T. Ostergaard, Ostergaard, & Lippert, 2004; Rall, Schaedle, Zieger, Naef, & Weinlich, 2002; Shalala & Herman, 2000; Shapiro et al., 2004; van Meurs, Couto, Couto, Bernardes, & Ayres-de-Campos, 2003; Wright et al., 2005; Wright, Taekman, & Endsley, 2004; Ziv, Ben-David, & Ziv, 2005; Ziv, Small, & Wolpe, 2000; Ziv, Wolpe, Small, & Glick, 2003).

Much of the stimulus behind this focus on patient safety dates to the Institute of Medicine 2000 report *To Err is Human: Building a Safer Health System* (Kohn, Corrigan, & Donaldson, 2000). This landmark study reported over 44,000 people and possibly up to 98,000 people die each year in United States hospitals from medical errors. The total annual cost of these errors is between $17 billion and $29 billion. Even more alarming is this represents only the hospital sector of the healthcare industry. The number of lives affected would be even higher if other parts of the healthcare system were included such as office-based practice, long term care facilities, and Emergency Medical Services. In its summary of recommendations, the report specifically mentions simulation as a possible remedy, stating, "…establish interdisciplinary team training programs for providers that incorporate proven methods of team training, such as simulation (p. 14)." The report further recommended simulation training as an example of injury mitigation activities:

> Another example of ways to prevent and to mitigate harm is simulation training. Simulation is a training and feedback method in which learners practice tasks and processes in lifelike circumstances using models or virtual reality, with feedback from observers, other team members, and video cameras to assist improvement of skills. Simulation for modeling crisis management (e.g., when a patient goes into anaphylactic shock or a piece of equipment fails) is sometimes called "crew resource management," an analogy with airline cockpit crew simulation. Such an approach carries forward the tradition of disaster drills in which organizations have long participated. In such simulation, small groups that work together—whether in the operating room, intensive care unit, or emergency department—learn to respond to a crisis in an efficient, effective, and coordinated manner.
>
> In the case of the operating room (OR) this means attempting to develop simulation that involves all key players (e.g., anesthesia, surgery, nursing) because many problems occur at the interface between disciplines. Although a full OR simulator has been in operation for some years at the University of Basel (Switzerland), the range of surgical procedures that can be simulated is limited. It will be a great challenge to develop simulation technology and simulators that will allow full, interdisciplinary teams to practice interpersonal and technical skills in a non-jeopardy environment where they can receive meaningful feedback and reinforcement. (p. 176-177)

Another government report from that same year also cited simulation as a valuable tool to improve patient safety. In *Doing What Counts for Patient Safety: Federal Actions to Reduce Medical Errors and Their Impact - Report to the President*, (Shalala &

Herman, 2000) made the following recommendations. “Develop and evaluate programs introducing health professionals to errors analysis and the challenges of practicing in a technically complex environment, explore the use and testing of simulators and automation as education tools, support training in errors research and evaluation…(Shalala & Herman, 2000, p. 17).” With this level of governmental comment and public awareness, healthcare professions education at all levels has had to respond to the issue of patient safety.

The level of concern for patient safety is recognized outside the United States. In Canada, it was estimated there were 70,000 preventable adverse events in Canadian hospitals with an estimate of deaths associated with those errors ranging from 9,000 to 24,000 (*Current state report on patient simulation in Canada*, 2005). The Canadian Patient Safety Institute supports the use of simulation as a means of ameliorating patient safety in Canadian hospitals. In the conclusion of its report on patient simulation, The institute stated:

> Growing awareness of adverse events in Canadian hospitals, combined with increasing emphasis on patient safety, has changed the traditional “learning by doing” approach to healthcare education. Anecdotal evidence reveals the promising potential of simulation to fundamentally change the way healthcare professionals practice and further hone their skills, interact across disciplines, and manage crisis situations. (*Current state report on patient simulation in Canada*, 2005, p. 23)

One of the strongest statements made regarding this aspect of simulation was presented by Ziv, Wolpe, Small, and Glick (2003). Under the title “Simulation-Based

Medical Education: An Ethical Imperative," the authors presented an argument that not using simulation was more than just an education issue, it was an ethical issue. As they report, there is often an over reliance on vulnerable patient populations to serve as teaching models when other resources exist that would provide adequate – if not superior – replacements. As they stated in their conclusion:

> We suggest that the proper and careful development of SBME [Simulation-Based Medical Education] is an ethical imperative. While the actual contributions that SBME can make to improving skills awaits empirical study, there seems little question that, when used in a sophisticated manner, SBME has the potential to decrease the numbers and effects of medical errors, to facilitate open exchange in training situations, to enhance patient safety, and to decrease the reliance on vulnerable patients for training. Moreover, by adopting simulation as a standard of training and certification, health systems will be viewed as more accountable and ethical by the populations they serve. (p. 786)

As mentioned, the education of healthcare providers requires a balancing act between providing the best in patient care while also providing learning opportunities for the healthcare professions student (Friedrich, 2002). Often, to protect patient safety actual patient contact is withheld in the healthcare provider learning process to a surprisingly late time period. J. A. Gordon, Wilkerson, Shaffer, and Armstrong (2001) made this observation:

> Medical students are usually excluded from the primary management of acutely ill patients, yet such experiences can be vital to the integration of basic and clinical sciences and to the development of basic medical skills. Not until

> internship do many young doctors experience first-hand the anxiety of being responsible for very sick patients, but by this point the risk of medical error may be unnecessarily high. (p. 470)

Several education institutions have advanced the concept of a simulation-based curriculum as a means of providing a meaningful learning experience for students prior to or concurrent with their introduction to patients in the clinical environment (J. A. Gordon, Oriol, & Cooper, 2004; McLaughlin, Doezema, & Sklar, 2002; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005). There are certain times during clinical training where an exceptional learning opportunity may exist, but the severity of the situation precludes the involvement of the student. As Hammond (2004) noted:

> Surgery, anesthesiology, and critical care are typified by the need for emergency care. This creates a poor context for learning in real-life situations due to the uncertainty of the process and the patient's responses, the complexity of the problem and possible confounding variables and simultaneous processes, time pressures, and stress. Little teaching takes place in the midst of a crisis, and in an emergency, the student or learner is often moved to an observer role, as the instructor or more experienced clinician takes over. (p. 236)

An important concept in the use of patient simulators in health professions education is the idea of crisis resource management. This topic is frequently mentioned in the literature (Blum, Raemer, Carroll, Dufresne, & Cooper, 2005; Blum et al., 2004; DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Flanagan, Nestel, & Joseph, 2004; Gaba, Howard, Fish, Smith, & Sowb, 2001; Glavin & Maran, 2003; Howard, Gaba, Fish, Yang, & Sarnquist, 1992; Lighthall et al., 2003; O'Donnell, Fletcher, Dixon, & Palmer, 1998; Rall, Schaedle, Zieger, Naef, & Weinlich, 2002; Reznek et al., 2003; Sica, Barron, Blum, Frenna, & Raemer, 1999). The concept of crisis resource management (CRM) is another area of simulation that has been adopted from the aviation industry. In aviation, CRM started out as Cockpit Resource Management, but later expanded to cover the whole of the airplane crew, thus becoming Crew Resource Management. CRM programs in health professions education started out in anesthesia training but have been adapted to other areas of medicine (Lighthall, 2004; Lighthall et al., 2003; Reznek et al., 2003). An early leading proponent and developer of CRM training in anesthesia was David Gaba at Stanford University (Flanagan, Nestel, & Joseph, 2004; Good, 2003). Many of the medical CRM programs currently in use can trace their origins to Gaba's early work. Interestingly, as a licensed pilot and an anesthesiologist, Gaba provided a special skills set to transition CRM from aviation to healthcare (Good, 2003).

Crisis Resource Management attempts to bridge the gap between knowledge and action. Connecting these two elements is vital. As Maudsley and Strivens (2000) stated, "In common usage, being 'knowledgeable' does not necessarily equate with critical thinking (p. 539)." Gaba, Howard, Fish, Smith, and Sowb (2001) demonstrated this in reviewing their experiences with student clinicians when they found the clinicians often had the knowledge but had difficulty with the interactional skills to effectively use this knowledge. They identified this as a shortcoming in health professions education.

Flanagan, Nestel, and Joseph (2004) described the major components of CRM training:

1. To enhance the participants' stock of precompiled plans for dealing with situations that could occur in their area of practice. That is, a refresher

course in relation to the medical management of a number of critical events.

2. To provide exercises that encourage the use of metacognition, situation awareness, and the avoidance of fixation error, the hallmarks of naturalistic decision-making.

3. To provide exercises in specific elements of resource management; managing the resources of the rest of the domain, including leadership, communication, teamwork, workload management, monitoring, and cross-checking. (p. 60)

One of the principle reasons patient simulation is being touted as a partial remedy for the medical errors crisis is its ability to impact on a particularly vulnerable time in the learning process. As Patow (2005) cited, the “learning curve” faced by many healthcare professions students is a source of medical errors. He continued, stating that the realism of many of the currently available simulators is quite high and allows for procedures to be practiced to mastery prior to being tested on real patients. But simulations offer much more than just practice:

> Learning procedures using advanced medical simulators is a step forward, but medical errors often result from ineffective processes and communication. After training in simulation centers, teams can stop to reflect on their own performance in detailed debriefing sessions. Reviewing video to discuss and learn from what transpired during a training exercise is an essential element of the learning process That kind of in-depth review is often not possible in real, fast-paced clinical settings. (Patow, 2005, p. 39)

The use of patient simulation in the training of healthcare providers is not limited to new students. There is also a need to maintain education in the health professions and simulation can be utilized effectively in this area as well (Ziv, Small, & Wolpe, 2000). As in other reports, Ziv, Small and Wolpe (2000) reiterated the shortcomings of the traditional model and explained that simulation was not just for the beginner:

> The reality of medical training is still that health professionals, whether novices or experts, are expected to continuously to acquire new knowledge and skills while treating live patients. The mode of training for gaining proficiency at risky procedures, as well as achieving and maintaining competence in handling rare, complex, and critical problems has been the classic on-the-job apprenticeship model based on *ad hoc* exposure to patients. (p. 489)

These authors feel simulation, when used across the continuum of health professions education, can make an impact on patient safety by removing patients from the risk of being practiced upon for learning purposes.

Gaba (2004b) pointed out there are also many indirect impacts of patient simulation on patient safety. These areas of impact include improvements in recruitment and retention of highly qualified healthcare providers, facilitating cultural change in an organization to one that is more patient safety focused, and enhancing quality and risk management activities.

A final point on patient safety is the ability to let healthcare providers make mistakes in a safe environment. In real patients, preceptors step in prior to the mistake being beyond the point recoverability or if the mistake occurs (particularly for those healthcare providers who are no longer students), there is a very limited instructive value to the case. As J. A. Gordon, Oriol, and Cooper (2004) commented, this type of instruction instills a valuable lesson:

> Consider the issue of patient safety, and imagine a practitioner who makes a clinical mistake; immediately after realizing the error, he or she will experience an emotional reaction that is powerfully instructive – but only for the next patient. What if educators could replicate such cognitive dynamics in a simulated environment, allowing trainees to "live through" a compendium of important cases in a fraction of real-time? At least for some medical students under this paradigm, simulation may allow complex information to be understood and retained more efficiently than would be the case with traditional methods, favoring early development of expertise in the formative years. (p. 24)

Ziv, Ben-David, and Ziv (2005) elaborated further, stating, "Total prevention of mistakes, however, is not feasible because medicine is conducted by human beings who err…[Simulation Based Medical Education] may offer unique ways to cope with this challenge and can be regarded as a mistake-driven educational method (p. 194)." They continued stating that Simulation Based Medical Education:

> …creates conditions in which making mistakes is not harmful or dangerous to patients but is, rather, a powerful learning experience for students and professionals. They are permitted to err and are provided with the opportunity to practice and receive constructive feedback which, it is hoped, will prevent repetition of such mistakes in real-life patients. (p. 194)

Realism

Learner perceptions of simulation realism have been reported in several studies and have generally been reported as being high (Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001; Feingold, Calaluce, & Kallen, 2004; Reznek et al., 2003). Maintaining a realistic environment is a key requirement for many simulations and an essential component for effective CRM training (Gaba & DeAnda, 1988; Hotchkiss & Mendoza, 2001). This not only means having a manikin device capable of adequately reproducing the patient condition, but also creating a learning environment that looks and feels like the real world. As Flanagan, Nestel, and Joseph (2004) noted, "Installing a simulator in a laboratory or conference room constrains the potential applications for which the device can be used (p. 38)." What is needed is an immersive environment that utilizes real medical equipment to make the simulation as like-like as possible. As described by Gaba and Small (1997) this is "Full Environment" simulation. Here the simulation is much more than just the manikin, as they stated, the simulation utilizes "a computerized surrogate mannequin patient, actual clinical equipment and staffing typical of the clinical environment (para 5)."

As Collins and Harden (1998) commented, "In general, the more realistic the patient representation, the more likely will the examination assess what the student will do in practice. Expecting students to communicate with a simulated patient whom they recognize as simulated may inhibit their performance (p. 517)." In simulation – not just medical simulation but in other simulation arenas as well – the ultimate achievement is the *suspension of disbelief*. It is at this point the participant becomes so involved in the scenario that it feels real. To achieve this, realism must be high.

However, when that level of simulation is reached, the impact on participants can be quite high. As J. A. Gordon (2004) recounted one of his learner's comments, "Initially I felt awkward being with a mannequin, but I must say, after a while I could really feel my heart pounding – it was a very visceral experience for me (p. 4)."

Another point to consider in regards to realism are the concepts first presented by Tulving and Thomson (1973). Their hypothesis stated that information is best retrieved when the cues for that information are encoded at the same time. Providing information in a setting that is void of the appropriate cues makes recall of the information much more difficult. Simulation-based training in a realistic environment complete with all cues allows the learner to encode both information and cues, thus improving their chances of successful recall later when the situation is presented in real life.

However, limitations in technology may have negative impacts on learner perceptions. Halamek et al. (2000) surveyed 38 physicians after completing a delivery room scenario with neonatal resuscitation. Using a three items scale (disagree, neutral, agree), the authors found a high satisfaction among the learner group. The majority of the negative comments were primarily directed at the lack of fidelity in the neonatal manikin, although they did rate the environment as a whole and the general nature of the simulations very favorably. Gaba and DeAnda (1988) in the introduction of their Comprehensive Anesthesia Simulation Environment (CASE) examined learner perceptions of the simulation in 17 residents and medical students. While learners rated the simulation environment as a whole very realistic, responses concerning the realism of the simulator itself were relatively low (means ranging from 4.4 to 5.6 on a 0 to 10 scale with 0 being *totally unrealistic* to 10 being *indistinguishable from the real thing*). It should be noted both studies (Gaba & DeAnda, 1988; Halamek et al., 2000) utilized simulators that were very early in development and these limitations were noted by the authors. However, it does point out that lack of realism might be a distracting factor for learners.

Patient Availability

A health professions student's ability to experience cases in the apprenticeship model is dependent on the natural flow of patients through the clinical environment and often becomes simply a matter of chance (J. A. Gordon & Pawlowski, 2002). A goal of any healthcare provider curriculum should be to provide all students with exposure to all types of relevant patients cases (Eder-Van Hook, 2004). Patient availability is not what it once was (Collins & Harden, 1998; Ewy et al., 1987; Kneebone, 2005). As Dent (2001) stated, "It cannot now be presumed that medical students may acquire competence in clinical skills by practising on patients as willing volunteers (p. 483)." Eder-Van Hook (2004) commented, "The trainee only learns from those cases and situations that present themselves within a short period of time a health care provider is in school (p. 6)."

Lane, Slavin, and Ziv (2001) commented on the problems associated with using real patients for basic teaching:

> In the clinical setting, there is no guarantee that every trainee will have a uniform clinical experience, see a representative patient mix, and learn all the necessary skills. Moreover, practicing clinicians who have trainees working with them might not be familiar with the learning goals and objectives or have the knowledge, attitudes, or skills to teach successfully…Simulation offers an alternative to learning with real patients and allows a wide range of skills to be

practiced and mastered. Specific learning goals and objectives can be defined, and all learners can successfully fulfill the goals and objectives, because learning takes place using trained instructors in dedicating teaching time rather than patient care time. (p. 298)

Simulation offers an ability to control the programming of the student's experiences. J. A. Gordon and Pawlowski (2002) commented about "the good teaching case" that can be programmed into a high-fidelity manikin-based patient simulator and be called up on demand by interested students. This function allows students in every clinical rotation to experience the same case that previously would have been limited to just a few students and possibly even a lone student.

Ewy et al. (1987) highlighted several of the problems posed in obtaining access to patients during the cardiology rotation of medical students. As they pointed out, bedside teaching with real patients was limited due to the fairly short time of the typical cardiology rotation, the lack of an adequate patient sample that was diverse enough to present with the range of cases needed, an out-of-balance student to patient ratio, and the general wear-and-tear on patients being exposed to multiple physical examinations for the sake of teaching students.

Additionally, some patient cases that were once relatively common are now exceedingly rare due to improvements in medications, monitoring, and procedures. Yet, they still occur and the clinician must be prepared for rapid and effective intervention (Fallacaro, 2000; Hotchkiss & Mendoza, 2001). As Macedonia, Gherman, and Satin (2003) pointed out, "Simulation offers educators the opportunity to expose trainees to experiences too infrequent or too medically risky to be found in common practice (para 10).”

Fiedor (2004) noted that pediatric cardiopulmonary arrest training can be difficult. Among the reasons she cited for this are differences in anatomy, different primary etiology of cardiac arrests, medication management is weight-based as opposed to the one-size-fits-all approach in adults, and lastly, the opportunity to learn the skills in the clinical arena are not common. As she stated, “Pediatric cardiopulmonary arrest is a relatively rare event, occurring one tenth as often per year as adult cardiopulmonary arrest. Thus, the ability to practice pediatric lifesaving skills in real time is limited (572).”

Student Availability

In medical education there are restrictions on the amount of time students spend in clinical and education activities (Eder-Van Hook, 2004; Greene, Zurakowski, Puder, & Thompson, 2006; Kneebone, Scott, Darzi, & Horrocks, 2004). This creates a new challenge on how to manage an ever-growing knowledge with limited exposure time for students. Dent (2001) commented:

> The prolonged apprenticeship-style training of the past is unlikely to be uniformly available for increased student numbers and in any case cannot be relied upon to provide adequate basic clinical skills training. In addition, expanded graduate-entry programmes will have to maximize the effectiveness of the reduced time available for clinical instruction. (p. 483)

Standardization and Replication

With real patients, there is always some degree of variability between patients – even those with the same disease process. For example, in a health professions student rotation, there may be a requirement to examine a congestive heart failure (CHF) patient. But variability in comorbid factors may make one CHF patient very different from another. In assessing student performance it is difficult to evaluate students equally across this variation. Simulation offers the ability to create standardization (Collins & Harden, 1998). Collins and Harden pointed out that through standardization, there is an improvement in the validity and reliability of evaluation techniques. As cited earlier by Lane, Slavin, and Ziv (2001) simulation offers the opportunity to standardize the goals and objectives of each case presentation. And with the ability to be reproducible, with each case being the same from student to student, there is greater equality in managing assessment (Bond & Spillane, 2002).

Along with standardization comes the ability to provide replication. As Hammond (2004) noted, “Simulation offers the advantages of prospective and repeated observations to events of known etiology (p. 325).” With this ability, all students may experience the same patient leading to equal learning experiences for all or the same students can experience the same patient repeatedly as he or she learns from each experience and builds better knowledge on how to manage this individual patient simulation.

This ability to standardize and replicate is critical in assessment of learner outcomes. Collins and Harden (1998) made this observation:

> In the clinical examination there are three variables: the student, the examiner, and the patient. The aim should be to standardize the examiner and the patient so that the student’s performance can be seen as a measure of his or her clinical competence. (p. 509)

With the variable of the patient removed through the standardization and replicability of the simulator, examination processes can be more fair.

Effectiveness of Simulation as a Teaching Tool

Several studies have been conducted that examined how simulation education compared with more traditional education formats, including the apprenticeship model. Studies have been conducted that demonstrated simulation efficacy through one-shot case study designs, one-group pretest/posttest designs, or one-group time series designs (Dobson, Brancati, & Nagel, 2003; Forrest, Taylor, Postlethwaite, & Aspinall, 2002; Hammond, Bermann, Chen, & Kushins, 2002; Marshall et al., 2001; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005; Morgan & Cleave-Hogg, 2000; Morgan, Cleave-Hogg, Desousa, & Lam-McCulloch, 2006; Rogers, Jacob, Rashwan, & Pinsky, 2001; Winston & Szarek, 2005). However, a fair number of studies have been published that used higher-level experimental designs, including randomized pretest/posttest control group experiments. Considering the number of these studies, the focus of this section will be limited to those higher-level experimental designed.

In the first high-fidelity manikin-based patient simulator study published, Abrahamson, Denson, and Wolf (1969) conducted a randomized experiment in which 10 subjects were assigned to one of two groups. The experimental group received endotracheal intubation training on the SimOne patient simulator (described in Chapter 1) while the other group received its training in the traditional format (operating room time in the apprenticeship model). Through expert observation and chart reviews, both groups were scored on a number of criteria including how long it took (in both days and number of cases) to reach various proficiency levels. Their findings showed significance (p =

.05) in the number of days it took to reach a proficiency level of 9 out of 10 successful procedures (45.6 days for the simulation group, 77.0 days for the control group).

Mayo, Hackney, Mueck, Ribaudo, and Schneider (2004) compared the effectiveness of patient simulation in the acquisition of advanced airway management skills in first-year internal medicine residents. Their study was a randomized experiment that conducted a pretest for all participants, and then assigned individuals to receive programmed advanced airway training using simulation or to go through the normal apprenticeship model of learning. Four weeks after simulation training, all subjects were again tested on advanced airway management skills. The intervention (simulation) group reached levels of significance on 9 out of the 11 factors being tested. This study also examined how the learning model translated to the bedside with real patients. After the delayed posttest was administered, all subjects who had not received simulation training then received simulation training. During the following 10-month period, expert raters scored the subjects responses to advanced airway cases and found that there was a uniformly high success rate at all individual skill points (range from 91% to 100% successful completion of task). The authors concluded this indicated a high transference of the simulation training to the real clinical environment.

Holcomb et al. (2002) reviewed the impact on performance after simulation training in trauma resuscitation in a pretest/posttest study. It should be noted that the study involved several groups receiving the same intervention at different time periods with the results then being combined. The study utilized an expert team as a comparison model. Their results showed that after the simulation intervention, the non-expert teams were able to perform at nearly the same level as the expert team, scoring lower in only 2 of 13 measurements.

Hall et al. (2005) compared paramedic students' ability to perform endotracheal intubations with one group receiving training on a patient simulator and the other group receiving the traditional apprenticeship model of performing the procedure on patients in the operating room. Their results showed that simulator training was as effective as real patient training as neither group performed significantly better than the other (p = .42). While this study did not show superiority for simulation, it was equal with a traditional method that utilized real patients for training.

Shapiro et al. (2004) conducted a pretest/posttest study that compared the impact of an emergency department team training course that included an 8-hour simulator session against another group that completed the same training but spent an 8-hour shift in the emergency department. Following the intervention, each group was observed and scored on team behavior. Comparisons between pretest and posttest scores on the level of team behavior showed the simulation group had improved, although the level did not reach significance (p = .07), while the group that completed a regular 8-hour shift showed no gains at all (p = .55).

Steadman et al. (2006) conducted a randomized experimental study that compared simulation-based training versus problem-based learning with 31 fourth-year medical students. Both groups underwent an initial simulator-based assessment of their clinical skills as a pretest. Subjects then underwent either simulation-based or problem-based learning workshops on managing patients with difficulty breathing (an ACLS-level skill). The groups were then crossed over to an additional workshop on abdominal pain in order to equalize simulator experience. Students were then retested on the management of a patient with difficulty breathing. Expert raters scored results of the pretest and posttest. While both groups had no significant differences in the pretest ($p = .64$), the simulation-based group had a highly significant advantage in performance in the posttest ($p = .0001$).

Ewy et al. (1987) conducted a multi-site pretest/posttest experiment with a control group. 116 medical students were assigned to receive cardiology training that included a high-fidelity cardiopulmonary assessment patient simulator while 92 received the standard cardiology training. Testing was done with both a multiple-choice examination and practical skills testing. In post testing, the intervention (simulator) group scored significantly higher ($p < .01$) than the control group. The practical skills testing showed the intervention group performed significantly better ($p < .001$) than the control group. This experiment also had the extra dimension of testing transference to practice as expert raters scored the students on assessment of actual patients. Again, the intervention group performed significantly better than the control group ($p < .03$).

Lee et al. (2003) randomly assigned 60 interns to one of two groups in a trauma orientation course in a posttest only control-group design. After completing the same initial component of the course that involved lectures and demonstrations, the subjects were randomly assigned to receive practice on a high-fidelity manikin-based patient simulator or with a live standardized patient with injuries replicated by make-up and moulage that reflected the traditional approach in an Advanced Trauma Life Support course. After this practice session, each group was further randomized to a second practice session with either the simulator or the standardized patient. Expert raters scored their performance. Their results showed the initial simulator-trained subjects performed significantly better than the initial standardized patient subjects ($p = .02$).

Wyatt, Fallows, and Archer (2004) conducted a randomized pretest/posttest control group study that examined the error rate in paramedics comparing simulation-based education with case-study based teaching. Their results showed simulation-based education had a significantly improved outcome greater than that of the case-study based teaching group ($p = .008$). Their study also indicated that error rates were most significantly reduced in the lesser-experienced subjects when compared to more senior subjects ($p = .014$).

Barsuk et al. (2005) conducted a prospective non-randomized quasi-experimental study comparing the outcomes of two groups of post-internship physicians in the management of airway crisis events. The first group was the control group who received the standard training intervention. The second group was the intervention group that included a simulation session in airway management (an ACLS-level skill). There were 36 subjects in each group. Comparisons between the two groups showed that the simulation group had a significantly reduced error rate ($p < .05$) in three of five clinical actions being examined and nearly reached significance in one other action ($p = .06$). However, in contrast to other studies of this type, Barsuk et al. refined the intervention group's program content based on errors seen in the control group. While this limits the ability of the study to show a group versus group comparison as in a static-group comparison study, it did show that simulation can be an effective tool in correcting errors.

Dalley, Robinson, Weller, and Caldwell (2004) conducted a randomized static-group comparison study of 18 anesthesiology students receiving training on a new anesthesia delivery system. One group received the standard didactic training on the device. The other group received that same training augmented with practical experience in the use of the device with a patient simulator. After training, both groups reported a high degree of confidence in their ability to use the device (p = .203). However, when examined in a practical posttest, the group whose training employed the simulator significantly outperformed the control group in two simulation scenarios in which device complications were introduced (p = .0113 and p = .0413).

Chopra, Gesink et al. (1994) conducted an experimental comparison study with 28 anesthesiologists and anesthesia students in which one group received simulator-based training on malignant hyperthermia while the other group received simulator-based training on anaphylactic shock. Four months later, all subjects were posttested on a malignant hyperthermia scenario. The group that received specific training in this anesthesia crisis event responded significantly better (p = .01) than the group who received simulation-based education on another anesthesia crisis and was reliant on actual clinical experience for learning how to manage malignant hyperthermia.

Pittini et al. (2002) conducted a pretest/posttest design study with three cohort groups that varied in level of experience. Their findings showed that while all groups improved in perinatal care, simulation had the most significant effect on learning in the most inexperienced group. The lowest level experience group made up of medical students and junior residents improved their skills to almost the same level as the more experienced fellows' group.

Problem-based learning has been well established in medical education as a efficacious learning technique (Barrows, 1996). Combining problem-based learning with simulation has significant potential. Euliano and Mahla (1999) reported on a technique to enhance problem-based learning with simulation. They presented a descriptive paper on their experiences detailing the advantages and disadvantages of combining these two learning techniques. Their conclusion indicated that the two learning strategies combined well, especially to fill in the void created between cognitive knowledge and practical application.

However not all studies have shown manikin-based simulation to have a positive impact on learning. McKenzie (2004) conducted an quasi-experimental study (non-randomized) with 38 medical students, with one group receiving pediatric resuscitation training in small-group teaching and the other with small-group teaching integrated with a high-fidelity manikin-based patient simulator. Posttest scores showed no significant difference between the two groups. However, it should be noted knowledge gain was determined by a written test rather than practical skills assessment.

P. J. Morgan, Cleave-Hogg, McIlroy, and Devitt (2002) conducted a randomized pretest/posttest experiment with 144 medical students comparing simulation-assisted education against video-assisted education in the management of patients with myocardial infarction, anaphylaxis, or hypoxemia. A simulator-based pretest was given to establish a benchmark. After the intervention, all subjects were again given the simulator-based scenario as a posttest. Expert raters scored both the pretest and the posttest. Posttest results showed that while there were significant educational gains in both groups, there was no statistical significance between the groups (*p* ranging from .09 to .92). One area of their study that did show significance between the groups was in the level of enjoyment of the experience and the perception of value. In these areas the simulator group scored significantly higher than the video group ($p < .001$).

Gilbart, Hutchison, Cusimano, and Regehr (2000) conducted a randomized posttest only control-group design study that involved one group receiving simulator-based education, another group receiving seminar-based education, and a third group receiving no education intervention at all in the management of trauma patients. The outcome measure was a surgical Objective Structured Clinical Examination (OSCE). Their results showed that learners in both the seminar and simulation groups significantly outperformed the no-intervention control group. However, there was no statistical difference between the seminar and simulation groups. The one positive finding for the simulation group was a higher perceived self-confidence.

Nyssen, Larbuisson, Janssens, Pendeville, and Mayne (2002) conducted an experimental comparison study with 40 anesthesiology students in which the intervention group received training with full-scale manikin-based simulation and the control group received training using a screen-based simulation. Their findings showed that while performance improved, there was no significant difference between the two groups. Due to the costs of high-fidelity manikin-based simulators, the authors suggested that there might be more cost-effective methods of providing simulation-based education. However, they did note that full-environment simulations might have impact in other areas that were not tested:

> Our results support the contention that screen-based simulators are good devices to acquire technical skills of crisis management. Mannequin-based simulators would probably provide better training for behavioral aspects of crisis

management, such as communication, leadership, and interpersonal conflicts, but this was not tested. (p. 1560)

Other forms of simulation, including some with fairly high fidelity, have been studied or reported. These include virtual reality simulation and screen-based simulation (Agazio, Pavlides, Lasome, Flaherty, & Torrance, 2002; Ahlberg, Hultcrantz, Jaramillo, Lindblom, & Arvidsson, 2005; D. Alverson et al., 2005; Caudell et al., 2003; Colt, Crawford, & Galbraith, 2001; Goolsby, 2001; M.S. Gordon, Issenberg, Mayer, & Felner, 1999; Hikichi et al., 2000; J. Jacobs et al., 2003; Kiegaldie & White, 2006; Kneebone et al., 2003; Liu, Tendick, Cleary, & Kaufmann, 2003; S. MacDonald, 1994; Mangan, 2000; Mayrose, Kesavadas, Chugh, Joshi, & Ellis, 2003; Moorthy, Smith, Brown, Bann, & Darzi, 2003; Reznek, Harter, & Krummel, 2002; Rowe & Cohen, 2002; Saliterman, 1990; Satava, 2001; Schendel, Montgomery, Sorokin, & Lionetti, 2005; Schwid & O'Donnell, 1990, 1992; Schwid, Rooke, Ross, & Sivarajan, 1999; Sedlack & Kolars, 2002; Sohmura et al., 2004; Székely, 2003; Tuggy, 1998). However, while these studies have made a contribution to the knowledge base of simulation, this study is limited to manikin-based simulation.

Simulation and ACLS

Franklin (2004) reported that of all the short-course certification programs such as ACLS, ATLS, PALS, and other similar programs, ACLS has the greatest potential for high-fidelity manikin-based patient simulation use. He said, “As sites gain access to an advanced patient simulator, the training and testing phases of ACLS are becoming more realistic. There are several advantages to the use of this technology, particularly with regard to a course such as ACLS (p. 399).” He continued, “With little effort, this experience can become totally immersive and provide a nearly realistic patient crisis (p. 400).” Schumacher (2004b) also reported that simulation could be an “effective strategy and tool for teaching advanced cardiac life support (p. 174).” Despite the promise of simulation in ACLS, no experimental studies on the use of high-fidelity manikin-based patient simulation in an actual ACLS course have been published. However, one descriptive report of using simulation in an ACLS course has been published (Ferguson, Beerma, Eichorn, Jaramillo, & Wright, 2004).

ACLS-level skills and high-fidelity manikin-based patient simulation have been studied by a number of researchers. As a sampling, specific ACLS skills that have been taught or evaluated using high-fidelity manikin-based simulation included airway management (Barsuk et al., 2005; Hall et al., 2005; Mayo, Hackney, Mueck, Ribaudo, & Schneider, 2004), respiratory compromise (Steadman et al., 2006), ECG rhythm interpretation and defibrillation (Mueller et al., 2005), and cardiac arrest management (DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Marsch et al., 2005).

Two published reports, both by the same lead author (Wayne et al., 2006; Wayne et al., 2005), covered ACLS course material in a manner that closely resembled an actual ACLS course and each of their studies involved one ACLS Instructor. However, neither study was an actual ACLS course that included all elements of the ACLS course and resulted in issuance of an American Heart Association course completion card. Nonetheless, these two studies warrant closer discussion.

Wayne et al (2005) conducted a randomized pretest/posttest controlled experiment with 38 second year internal medicine residents. Their study featured a crossover design that provided the simulation-based education intervention to the control group after the first posttest. Three comparison measurements were made: baseline, after either the simulation-based intervention (treatment group) or three-months of clinical activity (control group), and after a simulation-based intervention (control group or three-months of clinical activity (treatment group). The simulation-based education intervention focused on ACLS patient cases and utilized ACLS course materials. Results showed that there was no difference between the groups at the baseline. At the second measurement, the treatment group receiving the simulation-based education intervention performed significantly better on a simulated ACLS patient case than the control group ($p < .0001$). On the final measurement, the control group (which had now received the simulation-based education intervention) performed significantly better than the original treatment group ($p < .05$).

As they described their results, Wayne et al.(2005) noted that based on the second measurement point's results, clinical experience alone was not adequate in comparison to an ACLS-like simulation-based education intervention. The authors noted that there appeared to be very little decay in the original treatment group's score after three months. The mean scores for testing at measurement 2 and measurement 3 were 265.6 and 256.15 respectively. However, the authors did not submit this finding to a statistical test. Still, this finding is relevant considering other authors have reported rapid degradation of skills after ACLS training (Kaye, Mancini, & Rallis, 1987; Kaye et al., 1985; O'Steen, Kee, & Minick, 1996; Stross, 1983).

Wayne et al. (2006) conducted a one-group pretest/posttest design study with 41 second year internal medicine residents. After baseline testing, the subjects participated in a simulation-based education intervention that mimicked many elements of an actual

ACLS course. Subjects received 4 two-hour simulation sessions with ACLS cases, and then were retested. Subjects who did not achieve a minimum passing score were remediated through additional simulation sessions. Remediation times ranged from 15 minutes to 2 hours. Posttest scores improved significantly with the intervention ($p < .0001$). However, as reported earlier in this chapter, low-fidelity manikin-based ACLS programs reported significant improvement as well (Boonmak, Boonmak, Srichaipanha, & Poomsawat, 2004; Marchette et al., 1985; Quan, Shugerman, Kunkel, & Brownlee, 2001; Waisman, Amir, & Mimouni, 2002).

Student perceptions of manikin-based simulation

Numerous studies have examined learner perceptions of manikin-based simulation. Different perceptions were evaluated and included level of satisfaction, improvements in self-confidence, feelings of simulation realism, and overall acceptance of manikin-based simulation as a learning strategy.

Acceptance

Several studies were identified that showed a high degree of acceptance by students of simulation as a learning strategy (Bond et al., 2004; Bond, Kostenbader, & McCarthy, 2001; J. A. Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Hammond, Bermann, Chen, & Kushins, 2002; Lighthall et al., 2003; Morgan, Cleave-Hogg, Desousa, & Lam-McCulloch, 2006; J. Weller, Robinson, Larsen, & Caldwell, 2004).

Bond, Kostenbader, and McCarthy (2001) examined the level of satisfaction with using a high-fidelity manikin-based patient simulator in 78 healthcare providers of varying backgrounds. Using a five-point Likert scale (1 equals *disagree completely*, 5 equals *agree completely*), subjects responded to five questions after a simulation session.

Results showed a very positive agreement that indicated a high degree of satisfaction with the simulation session. Responses ranged from 4.53 to 4.77. In qualitative comments that were solicited, the most frequent responses referenced the realism of the simulation and the ability to see the results of therapeutic decisions.

Lighthall et al. (2003) surveyed 181 healthcare providers after completion of a CRM course focused on intensive care unit patients. Their results showed participants heavily supported simulation-based education, although medicine and anesthesia residents indicated having a greater liking for the program than surgery residents. During debriefings associated with the scenarios, validity of the program was established as there was uniform agreement that the errors highlighted in the simulation sessions were errors that were commonly seen in hospital-based practice.

Bond et al. (2004) conducted a qualitative assessment of 15 emergency medicine resident physicians after utilizing a high-fidelity manikin-based patient simulator for the assessment and treatment of a renal failure patient with hyperkalemia. Through a combination of verbal questioning by an ethnographer and a series of survey questions utilizing a Likert-like scale (1 equals *disagree completely*, 5 equals *agree completely*), the authors found that the residents were very favorable to simulation as a learning strategy, ranking it second only to direct patient care in terms of how effective it was educationally. On individual items related to knowledge gain, the subjects rated the simulation highly with a mean range of responses being 4.6 to 4.73. Subdividing the results between second year and third year residents, the authors noted a difference in what was learned. The less experienced physicians tended to state that the knowledge they gained was related to treatment specifics, such as the use of various medications or other therapeutic interventions. The more senior physicians tended to state they learned more about their own cognitive processes in the decision-making in the management of the simulated patient. The authors concluded the simulation sessions were not only valuable in teaching specifics about patient care interventions, but also useful in developing metacognition strategies.

Morgan, Cleave-Hogg, Desousa, and Lam-McCulloch (2006) surveyed 226 medical students on their experience after completing a simulation-based education program. Using their five-point scale (*strongly disagree* to *strongly agree*), the overwhelming majority of students rated the experience highly (either agree or strongly agree in all areas. The learners felt the simulation was realistic, represented the learning objectives, was a valuable learning experience, and helped link theoretical aspects of care to practical applications.

J. A. Gordon, Wilkerson, Shaffer, and Armstrong (2001) conducted a one-shot case study survey of a convenience sample of 27 medical students and 32 medical educators after introducing a high-fidelity manikin-based patient simulator to each group. Both groups responded very favorably to simulation as a learning tool with 85% of students rating the experience as excellent with 89% of the students saying simulation should be a mandatory part of the curriculum. For the educators, 89% rated the session as good or excellent while 82% stated simulation should be part of the curriculum.

J. Weller (2004) conducted a one-group pretest/posttest survey of 33 medical students participating in an anesthesia workshop. Weller described her study as using a medium-fidelity manikin-based patient simulator; however, she used the same simulator being used in this study (Laerdal SimMan). As discussed in Chapter 1, fidelity is a fairly subjective term that has different meanings depending on the use of the device. Her findings showed that learner self-reported measures of confidence in providing care significantly increased after participation in the workshop ($p < .0001$). Written responses from the students after the workshop indicated enthusiastic acceptance of the simulator as a learning tool and responses indicated students felt the workshop very beneficial. When asked to identify key learning points of the workshop, it was interesting to note that the clinical objectives such as assessment and therapeutic interventions were not the most frequently mentioned. Behavioral issues such as teamwork, leadership, and critical thinking skills were identified as the key learning points of the workshop.

Feingold, Calaluce, and Kallen (2004) surveyed 65 undergraduate nursing students on their views of using simulation as a learning strategy in clinical skills laboratory. Their results showed that learners felt the simulations provided realism sufficient for the skills being taught, and had considerable overall value to the learners' ability to learn new skills and knowledge. About half of the learners felt there was a high degree of transferability of the skills from the simulation laboratory to the real clinical setting. One significant finding discovered in subgroup analysis of their data was that learners with lower self-reported Grade Point Average felt the simulation experience was of greater value than those with higher self-reported GPA.

Confidence

Learner self-reports of confidence in their ability to provide patient care after simulation-based education have been positive (Bearnson & Wiker, 2005; Euliano, 2001; Feingold, Calaluce, & Kallen, 2004; Gilbart, Hutchison, Cusimano, & Regehr, 2000;

Henrichs, Rule, Grady, & Ellis, 2002; Marshall et al., 2001; Meier, Henry, Marine, & Murray, 2005; O'Brien, Haughton, & Flanagan, 2001; Wayne et al., 2006).

Experience plays a significant role in the development of healthcare provider confidence (Morgan & Cleave-Hogg, 2002). Confidence is vital to the clinician taking action. As Maibach, Schieber, and Carroll (1996) noted, even clinicians with adequate knowledge and skills may be reluctant to take appropriate action unless they are confident in their abilities. In reviewing the literature, learner feelings of self-confidence tend to be improved when the learning experience is simulation-based. Euliano (2001) reviewed the results of student evaluations of a simulation-based course that also utilized problem-based learning techniques. Using a pretest/posttest design, learner confidence in their knowledge of the material significantly improved after participation in the simulation program ($p < .0001$). Additionally, learners rated the course with a mean of 4.5 out of 5.0, which rated among the highest rated courses in the medical school where the course was conducted.

Henrichs, Rule, Grady, and Ellis (2002) performed a qualitative study of 12 first year nurse anesthesia students to determine their perceptions about simulation as a learning strategy. Their results identified 11 items that were positively perceived by the learners. This included, in rank order:

1. Improved critical thinking and decision-making skills
2. Ability to learn crisis resource management skills
3. Ability to learn how to administer anesthesia without causing harm
4. Vital part of nurse anesthesia education
5. Simulated reality of anesthesia environment

6. Increased confidence level

7. Evaluation of cognitive and psychomotor skills

8. Ability to learn about rare events or unusual complications

9. Ability to critique actions per videotape of self and classmates

10. Motivation to learn more about a specific topic

11. Improved leadership skills (p. 222)

Henrichs, Rule, Grady, and Ellis also identified several negative perceptions, including learners' lack of knowing what to do in the situation, a tendency to experience fixation errors, increased anxiety, and a lack of reality at all times. As this study was performed with first-year students, some of these negative factors such as anxiety and fixation errors may correlate to their experience level with nurse anesthesia in general.

Wayne et al. (2006) conducted a follow-up survey with 40 second year internal medicine residents after having completed an ACLS-like simulation-based education program. They reported that the subjects were uniformly positive about the ability of the simulation-based education experience to increase their clinical capabilities and improve their confidence to respond to ACLS emergencies in the clinical setting. Subjects also reported they felt they were better team leaders as a result of the intervention.

Even in comparative studies where differences in observed learning between two or more groups was not significant, learners' from the simulation intervention group still had a higher self-reported feeling of confidence. Gilbart, Hutchison, Cusimano, and Regehr (2000) surveyed their study's participants and found that 100% of the simulation group learner felt clinically competent to manage a trauma patient while only 82% of the seminar group felt confident. Griggs (2003) reported increased learner self-reported competency in a randomized pretest/posttest controlled study. However, the reported perceptions of competence had improved for both the control and experimental (simulation) groups and there was no statistical significance between the two.

Learner Satisfaction

Learner satisfaction has been reported as being very positive after manikin-based simulation-based education programs (Block, Lottenberg, Flint, Jakobsen, & Liebnitzky, 2002; Cleave-Hogg & Morgan, 2002; Morgan, Cleave-Hogg, McIlroy, & Devitt, 2002; von Lubitz et al., 2003).

Cleave-Hogg and Morgan (2002) conducted a survey of 145 fourth-year medical students after completion of an anesthesiology rotation in a patient simulation laboratory. Participants completed a seven-item questionnaire with a 5-point Likert-like scale (1 being *strongly disagree*, 5 being *strongly agree*) and answered additional open-ended qualitative questions. The quantitative results showed a significant preference for simulation as a learning model, with most responses being in the agree or strongly agree column. One interesting note on the quantitative results was on the questions related to the participant being "comfortable" in the simulator room. This question had the highest number of strongly disagree and disagree responses of any question. One student commented, "It was too anxiety provoking and overwhelming a situation to actually learn from (p. 25)." Stress or fear as a issue in patient simulation is a factor and has been reported by others (Bond et al., 2004; Henrichs, Rule, Grady, & Ellis, 2002; Kapur & Steadman, 1998). However, this may be a testament to the realism of the simulation session, as stress in real events would be expected to be high as well (Aronson, Rosa, Anfinson, & Light, 1997; Kneebone et al., 2002). Qualitative comments showed students responded very favorably to simulations. One student stated, "Realism promoted reinforcement of book-learned concepts…putting knowledge into practice was invaluable (p. 25)." Another commented, "We don't get much opportunity to run codes [cardiac arrests] in real life. Excellent opportunity to get hands on experience without risk of harming patient. This is almost a 'real life' experience (p. 25)."

Block, Lottenberg, Flint, Jakobsen, and Liebnitzky (2002) conducted a one-shot case study of 14 participants in an Advanced Trauma Life Support course. Their survey results showed the students felt the manikin was better than the previous model used in the course (a live anesthetized animal). However, while the patient simulator in this course represented excellent fidelity for the task being taught and tested, it did not represent a full-bodied manikin.

Patient Perceptions

Not all studies have focused on the healthcare learner as their subjects in examining perceptions about simulation. Graber, Wyatt, Kasparek, and Xu (2005) conducted a survey of 151 visitors to an emergency department to determine how simulator use influences patients' perceptions about medical students performing skills in the emergency department. Subjects were asked how many procedures after demonstrating competence on a patient simulator a medical student should do before the subjects would let that student perform the procedure on them. Results were compared with a similar study that did not include the simulator aspect of the question. The results showed that simulator training changed patient perceptions about allowing a medical student to perform procedures on them. Of the nine procedures covered in the survey, results were significantly different ($p < .03$) in six of the procedures, indicating that patients were more accepting of medical students doing procedures on them when the medical student had simulator training.

Limitations of Simulation

While realism has been achieved in many areas of patient simulation, there are still many other areas of patient anatomy and physiology that have yet to be realized. As Hammond (2004) noted, “The major hurdles facing medical education are to expand the fidelity of the modeling and to create a business case for simulation centers (p. 325).” Others have also commented on the lack of realism in some areas, including the feel of the skin, skin color, and skin temperature (Euliano, 2001; Good, 2003; Haskvitz & Koop, 2004). The lack of realism may not just apply to the simulation device. Morton (1997) commented on the ability of the environment to be recreated, saying:

> …simulation is constrained by the degree it can mimic reality. The fast-paced, high-stress environment of a critical care unit is difficult to simulate. As a result, there is no assurance that the learner will make a smooth transition of knowledge from the simulated situation to the actual clinical environment. (p. 67)

Kneebone, Scott, Darzi, and Horrocks (2004) warned against an over reliance on simulation as being a replacement for actual clinical experience. Simulation competence may lead to overconfidence on the part of the learner creating a dangerous situation when the learner takes those skills to the clinical arena. They stated, “There is also a danger that simulation may become an end in itself, disconnected from the professional practice for which it purports to be a preparation (p. 1099).” Gilbart, Hutchison, Cusimano, and Regehr (2000) lend credence to this viewpoint as 100% of their simulation-based learners felt confident about their ability to provide care while only 83% of a comparison group felt confident, despite finding there was no significant difference in either group to provide adequate patient care. However, it could not be determined if this was a matter of overconfidence in the simulator group or underconfidence in the comparison group.

One problem with high-fidelity manikin-based patient simulators is that they are mechanical. Breakdowns do occur. Bond, Kostenbader, and McCarthy (2001) and Henrichs, Rule, Grady, and Ellis (2002) noted some dissatisfaction with breakdowns in their studies of healthcare providers' experience with simulation sessions. Bond, Kostenbader, and McCarthy (2001) also showed some dissatisfaction in their subjects' qualitative comments with the simulator making mechanical noises during some assessment procedures.

Cost remains an issue with simulation courses as the purchase of the simulators, equipping the simulation room, providing maintenance, and training faculty and staff still remains relatively high (Dent, 2001; Euliano, 2001; Farnsworth, Egan, Johnson, & Westenskow, 2000; Good, 2003; Haskvitz & Koop, 2004; Hotchkiss & Mendoza, 2001; Issenberg, McGaghie et al., 1999; Morton, 1997; D. Murray et al., 2002; Nehring, Ellis, & Lashley, 2001; Nyssen, Larbuisson, Janssens, Pendeville, & Mayne, 2002; Wang & Vozenilek, 2005).

While there has been a fair amount of research conducted on simulation as a teaching strategy in healthcare provider education, more needs to be done (Bradley, 2006; Hotchkiss & Mendoza, 2001). Just as evidence-based medicine has become an expectation in patient care, evidence-based education is becoming a higher priority in many healthcare provider curriculums. Once such manifestation of this movement is the Best Evidence Medical Education program (Issenberg, McGaghie, Petrusa, Lee Gordon,

& Scalese, 2005). One issue that creates problems for simulation-based education research is the small sample size of many studies (Bradley, 2006). Other authors (Beaubien & Baker, 2004; J. Cooper & Taqueti, 2004) also suggest more research is required, particularly research that shows improvements in patient safety. Another issue regarding simulation research is the inability to establish congruent findings. Gilbart, Hutchison, Cusimano, and Regehr (2000) noted this as they reviewed the literature regarding transference of skills from simulation to the real world clinical environment.

While simulation has been studied in a wide variety of healthcare provider curriculums and is continuing to grow in its use, it is not yet pervasive as an educational tool. J. Cooper and Taqueti (2004) stated the “tipping point” has not yet been reached in simulation in all healthcare fields. One reason they cite for a portion of this problem is the reimbursement problems for healthcare providers and educational organizations. Good (2003) mentioned that simulation may be intimidating to some healthcare provider learners. However, he added that several studies have shown excellent acceptance for simulation as a learning strategy.

Nehring, Ellis, and Lashley (2001) also noted the limited number of learners that could utilize the simulator at one time. Simulation-based education limits activities to small groups or possibly even single learners. Other formats such as lecture, demonstration, or web-based instruction can allow for larger groups or more simultaneous users.

Good (2003) stated that faculty development may be a problem. As in many areas of education, faculty staffing and work requirements are stretched. Teaching with simulation requires a whole new skill set that many faculty members do not currently have. In addition to the teaching techniques required (such as debriefing) there is the technology to learn. While many simulation centers employ simulation technicians to manage this aspect, this is not universal and the faculty member may be called upon to manage the technology. Feingold, Calaluce, and Kallen (2004) and Nehring, Ellis, and Lashley (2001) also reported faculty concerns that simulation would require additional time and resources beyond their normal teaching responsibilities.

Haskvitz and Koop (2004) noted that learners in a simulation are probably in a state of heightened awareness and anticipation, waiting for something to happen. As they stated, “Students may aggressively tune into the possibility that something is about to happen and become overzealous in treating a situation (p. 184).” This does not represent the real world well as most care may be routine and the clinician may drop his or her guard and be caught unawares of the developing crisis situation. Coupled with the idea that something is going to happen, Henrichs, Rule, Grady, and Ellis (2002) found that students in their study experienced feeling like a “sitting duck (p. 223).” This feeling created a higher level of anxiety than they would have experienced in the real clinical environment.

As mentioned earlier in this chapter, anxiety on the part of the student may be a problem with simulation. While the stresses of learning in the real world clinical situation are well documented, there is a different kind of stress in the simulation setting that must be taken into account, especially in evaluation scenarios. As Kapur and Steadman (1998) stated:

> The simulator environment may prove to be intimidating to candidates at first. The presence of video cameras, evaluators, scripted roles for co-actors in the

scenes, and limited flexibility of the programmed scenarios to accept alternative therapeutic pathways or thought processes that avoid harm and achieve acceptable results could potentially lead to a false-negative test, in which the candidate could be deemed incompetent in the simulator situation, yet be an entirely acceptable clinical anesthesiologist under less artificial conditions. (p. 1158)

Another drawback noted by Greenberg, Loyd, and Wesley (2002) is that despite technological advances in simulator fidelity, simulators do not convey “humanness (p. 1109).” Simulators are cold and plastic in appearance and even with the capability for a human voice to be generated via microphone and speaker, there are limits to how real the devices can seem. To counteract this deficit, Greenberg, Loyd, and Wesley devised a program where standardized patients are incorporated into the scenario and utilized up until the point actual procedures start. Kneebone et al. (2002) and Pittini et al. (2002) developed similar systems with part-task simulation.

Issenberg, McGaghie et al. (1999) pointed one other area of concern for simulation technology. They commented that there is some fear that technology will dehumanize health care. Simulation technology removes the health professions student from interacting with the patient and decreases total time spent with real patients. These authors felt that simulation training served the patient’s best interest by placing a better prepared clinical student at the bedside. Ziv, Wolpe, Small, and Glick (2003) agreed with this point, stating, “Although overreliance on technological medicine may sometimes be a threat to humanistic care, the proper use of simulation technology has the potential to enhance humanistic training in medicine (p. 786).”

Morton (1997) warned of another potential issue with simulation. She stated that simulations might be heavily oriented to the psychomotor skills. As such, learners develop an emphasis on the technology often associated with those skills. Doing this “deemphasizes human caring…Yet, to become a caring nurse requires a measure of comfort and competence with technology so that technology no longer is the focus of care. Instead, the patient becomes the focus (p. 68).”

Simulation in Nursing Education

High-fidelity manikin-based patient simulation has been conducted with a variety of health professions students and practicing healthcare providers as noted in Chapter 1. While the majority of published studies focus on medical (physician) education, the application and benefits of patient simulation are similar for nursing (Feingold, Calaluce, & Kallen, 2004). Peters (2000) and Yaeger et al. (2004) stated that the medical education model and the nursing education model have many similarities, although both are going through reform. This study used nursing students as subjects. Simulation-based education has frequently been reported in the nursing literature and it uses in nursing education are many (Schumacher, 2004a, 2004b).

While most of the studies on patient simulation have focused on simulation in medical education, nursing represents a significant audience for patient simulation. Many of the same challenges facing medical education are also apparent in nursing education, including the continuing growth of medical knowledge, patient safety, and patient availability. Complicating matters for nursing education is an unprecedented demand for nurses in today’s health care market, with nursing shortages expected to reach as high as 20% by 2020 (Eder-Van Hook, 2004). Larew, Lessans, Spunt, Foster, and Covington

(2006) noted that simulation in nursing education started with “teaching psychomotor skills and competency testing. Use in nursing curricula has expanded to include development of critical thinking and the practice of skills within the affective domain (p. 17).”

Nehring, Ellis, and Lashley (2001) noted that modern high-fidelity manikin-based patient simulation has great potential in nursing education:

> The psychomotor skill laboratories in nursing education have grown from the infamous Mrs. Chase and other crude mannequin-driven laboratory projects of the early part of the last century to the advanced simulation environment of today. This has been accomplished through the integration of medical and nursing education with the emerging and expanding computer technology, such as the HPS [Human Patient Simulator], available throughout the world. This has been done to insert the learner into a more realistic simulation environment where the development and application of knowledge, skills, and the practice of protocols can be enhanced. Opportunities for education, research, and evaluation using the HPS at all levels of nursing education are limitless. (p. 202)

Nehring and Lashley (2004) conducted and international survey of 34 schools of nursing and six simulation centers on the use of high-fidelity manikin-based simulators in use in nursing education. The authors noted that simulation use in nursing education programs was not yet well developed, especially in comparison to simulation use in medical education. They also noted that reports on the use of patient simulation in the nursing literature were very few. Among their descriptive findings:

- of the 34 nursing schools, 82% were public institutions

- the nursing schools offered a range of degrees from associate to graduate
- 16 were community colleges, 18 were universities
- The simulator was most frequently reported being in use in associate degree programs, with associate degree programs also showing the most hours of use
- Community college use tended to be focused on assessment skills while university use tended towards higher level problem-solving and interventional skills

Bearnson and Wiker (2005) conducted a one-shot case study of the impact of a simulation-based education program on post-operative pain management by student nurses in a baccalaureate nursing program. The measurement instrument was a self-administered instrument that evaluated student opinions on the learning experience and their self-efficacy in the management of post-operative pain. Using a Likert-like scale of 1 (*strongly disagree*) to 4 (*strongly agree*), the students responded to four questions. Mean scores ranged from 3.0 to 3.31. The authors concluded that simulation could be a valuable asset to nurse training.

Feingold, Calaluce, and Kallen (2004) conducted a one-shot case study (however, it included two groups from two different semesters that were combined for reporting). Sixty-five baccalaureate degree nursing students were included in the study. Their findings included very high scores for student agreement with the realism of the simulation and its value to learning (84.6% and 92.3% respectively). Additionally, the participants viewed the simulation as a good test of their clinical skills (83.0% agreement) and their decision-making (87.7% agreement).

Farnsworth, Egan, Johnson, and Westenskow (2000) did a one-group pretest/posttest study with 20 Registered Nurses involved in conscious (moderate) sedation patient interventions. Written pretest and posttest comparisons showed that after simulation-based education, posttest scores improved significantly (p = .001). In a simulator-based practical evaluation of the concepts taught in the program, mean practical score was 5.5 out of a possible 6 (with 0 being the lowest possible score).

Haskvitz and Koop (2004) Suggested a model of remediation for nursing students performing at a suboptimal level in clinical rotations. Citing patient safety as a major motivating factor, nursing clinical preceptors and educators have a responsibility to improve the educational outcomes of their students while still protecting patient safety. Through the use of a patient simulator, the authors introduced a program to remediate nursing students who needed additional help in grasping clinical concepts and skills. Their process identified four steps:

- Assessment – Determine what areas need improvement. Not all areas can be effectively remediated with simulation. Issues related to preparation, didactic knowledge, and professionalism may need to be addressed elsewhere. Simulation does lend itself well to problems associated with integrating didactic knowledge into the clinical setting, performing a skill, or implementing a plan of care in prioritized manner.
- Planning – Simulation scenarios need to be developed that address the learner’s deficiencies. Objectives should be reviewed with the learner and the preceptor. The learner should be instructed to prepare for the simulation in the same manner in which he or she would in preparing for a clinical day.

- Implementation – The learner interacts with the simulator in the prescriptive scenario. The instructor or preceptor may have the learner repeat the scenario until the desired level of competence is achieved. The scenario could be interrupted to supply appropriate feedback on actions taken by the learner.
- Evaluation – Once the simulation scenario is complete, debriefing should performed that summarizes the objectives and includes how the learner achieved each of those objectives. Learners would be encouraged to identify areas where additional improvement may be needed. Lastly, preceptors should monitor learner performance in the actual clinical environment to ensure that the simulation behavior of the learner transfers to the clinical realm.

Bremner, Aduddell, Bennett, and VanGeest (2006) conducted a one-shot case study survey of 41 novice nursing students using a manikin-based patient simulator for performing a patient assessment. Their results showed the vast majority of these novice nursing students felt the simulation was a valuable tool for learning and should be a mandatory part of the curriculum. Sixty-one percent of the learners stated the simulation session gave them greater confidence in performing a patient assessment.

As with simulation in general, not all studies in nursing's use of simulation have demonstrated favorable findings for simulation compared to other learning methodologies. Ravert (2004) conducted a randomized pretest/posttest design with 25 third semester nursing students comparing two types of learning strategies: classroom-based discussion for one group and simulator-based education for the other group. Her findings showed both groups significantly increased their critical thinking skills. Both groups also reported significant gains in self-efficacy, However, neither group significantly outperformed the other in either area.

Alinier, Hunt, Gordon, & Harwood (2006) conducted a randomized pretest/posttest study of 99 diploma-level nursing students. Two groups were tested: one that went through the normal curriculum and another that had their curriculum supplemented by simulation-based education. Upon testing using an Objective Structured Clinical Examination, both groups demonstrated significant increases in their ability to access patients ($p < .0001$). However no intergroup differences were noted in learning gains. Additionally, both groups' perceptions of stress and self-confidence scored equally as well.

Simulation and Team Training

Team leadership has long been identified as a problem in ACLS courses and ACLS-level care (Kaye & Mancini, 1986). As Kay and Mancini noted, "During training, assessment of both the patient and the team, and troubleshooting must be explicit and well understood. Optimal assessment and troubleshooting skills of the team leader will maximize the likelihood of a successful resuscitation (p. 103)." Simulation offers an opportunity to more effectively practice and evaluate team leadership as it allows the instructor to step back from the teaching scenario and allow the team to function in a more independent manner.

Another factor affecting team management is the changing role of the physician (Dent, 2001). Rather than the traditional authoritarian role of the physician, physicians are now being seen as team members in multidisciplinary teams with a blurring of boundaries in responsibility and roles. Directly related to patient safety concepts embedded into Crisis Resources Management programs, modern healthcare teams differ greatly from their predecessors.

Reviewing learning teams in general, Kayes, Kayes, and Kolb (2005) summarized several negative behaviors that tended to surface in groups. These included:

- over reliance on a single dominant person as team leader,
- tendencies to resort to groupthink were individual members cede their independent thought to conform to the group, even when the group decision is wrong, such as making riskier or more conservative decisions than individuals would have made alone,
- diffusion of responsibility in which individual members of the group shirk responsibility thinking that someone else will assume that responsibility,
- social loafing where individual group members loose motivation creating a situation in which the group's results are less than what the individual results could have been, and
- the Abeline paradox where individual members consent to group actions against their own judgment, failing to express their opinions.

It is this team approach that must be addressed to have a substantial impact on patient safety and healthcare outcomes. As Hamman (2004a) noted in comparing aviation incidents with adverse medical events, it is typically not a single individual or a piece of equipment that fails. It is more typically a team that fails. Training at this level has to involve more than just focus on the individual. Whole teams must be evaluated. As Hamman observed, in healthcare, training is focused at the individual with the intent of making that individual a better clinician. Henriksen and Moss (2004) stated that, "Health care providers work together, but are trained in separate disciplines. Few receive training in teamwork (p. i1).” Integrating that individual and his or her knowledge into the more complex interactive requirement is not the focus of most healthcare education programs. Hamman (2004a) created a five-step process for developing team simulations in medicine:

1. Identify team topics and subtopics, linking performance indicators to objectives.
2. Select incidents to simulate, preferable from a data set of real events.
3. Identify objectives and the observable behaviors that will indicate their completion as tracked by a validated assessment instrument.
4. Test the simulation scenario with at least two different expert teams and confirm validation of the assessment instrument.
5. Modify and finalize the simulation based on expert team feedback and deliver simulation scenario to its intended audience.

Experiential learning (covered in greater detail later in this chapter) in teams can be credited to Kurt Lewin in his work in the 1940s (Kayes, Kayes, & Kolb, 2005). For teams, reflection is an important process for improving team function. Kayes, Kayes, and Kolb (2005) cited principles that have they deduced from a review of research on experiential learning in teams in general. Their three principles were:

- “To learn from their experiences, teams must create a conversational space where members can reflect on and talk about their experiences together (p. 332).” Objectivity is essential in this conversational space. The team must see itself in a true light. If this is not achieved, the team is “flying blind. (p. 333).”

- “As a team develops from a group of individuals into an effective learning system, members share the functional tasks necessary for team effectiveness (p. 333).” Team members must develop a shared responsibility. No one person assumes the role of the traditional team leader.
- “Teams develop by following the experiential learning cycle. (p. 333).” This process – concrete experience, reflective observation, abstract conceptualization, and active experimentation – is reviewed later in this chapter.

For teams to learn, some form of intervention is required. Natural development is an unreliable way to improve performance (Kayes, Kayes, & Kolb, 2005). Simulation offers a “programmed team learning experience (Kayes, Kayes, & Kolb, 2005, p. 350)” For experiential learning to work for team development and acquisition of new knowledge, four components must be in place for team members, with one component for each of the four segments of the experiential learning cycle. Team members must be…

- involved and committed to the team and its purpose and who are creating new knowledge and identifying challenges (concrete experience).
- engaging in reflection and conversation about the team’s experiences and making observations to ensure that all available knowledge has been addressed (reflective observation)
- thinking critically about how the team works and coming up with new theories, devising plans, models, and placing abstract events into coherent and simple explanations (abstract conceptualization)

- making decisions, taking action, and experimenting with various approaches and strategies for problem solving (active experimentation) (Kayes, Kayes, & Kolb, 2005, p. 350)

Ostergaard and colleagues (D. Ostergaard, 2004; H. T. Ostergaard, Ostergaard, & Lippert, 2004) discussed the current state of team training in a variety of medical disciplines and presented information on their development of team training programs using simulation. One area on which they focused was ACLS training. Upon reviewing their own hospital's activities, they found that application of treatment guidelines was inconsistent and through focus group interviews found that communication and leadership skills were poor. In response to this information, a specialized training program in ACLS-like course that utilized high-fidelity manikin-based patient simulation was developed. In a one-group pretest/posttest design study, they showed that self-evaluation of communication, cooperation, and leadership improved dramatically from pretest to posttest.

However, there has been contradictory information presented as well. Blum, Raemer, Carroll, Dufresne, and Cooper (2005) noted a key component of effective healthcare team performance is the ability to effectively share information. They conducted a one-group pretest/posttest design study that examined communication sharing. In their study, critical patient information was inserted into the scenario by a role-playing research staff member to one of the team members participating in the scenario. As predicted in their first hypothesis, information sharing between team members was very low with only 27% of the planted information being shared among team members. However, their hypothesis that debriefing and a didactic education session from the Anesthesia Crisis Resource Management (ACRM) course would improve team communication and information sharing failed to show significance during posttest.

Simulation Learning Theory

Patient simulation has become well entrenched in many healthcare provider curriculums. Healthcare educators who have promoted simulation as a learning model are quick to point out many of the advantages patient simulation offers and there are great expectations for simulation. J. A. Gordon, Oriol, and Cooper (2004) discussed this potential:

> High-fidelity patent simulations – full-bodied mannequin-robots that breathe, talk, blink, and respond “like a real person” – promise to play a revolutionary role in undergraduate medical education. Allowing students to “practice without risk” on the simulator creates a powerful new framework for the thoughtful integration of basic and clinical science, long a goal of medical educators worldwide. (p. 23)

Considering the hopes that are pinned to simulation as a means of improving healthcare providers’ learning while at the same time increasing patient safety, an exploration of why patient simulation works as a learning strategy is warranted.

In reviewing the simulation literature – both in healthcare simulation and the more general view of simulation – a variety of education theories are presented as supporting simulation’s use. However, no one theory has emerged as being explanatory of the whole field of simulation. Kneebone (2006) commented:

> If simulation is to be fit for purpose, we need to elaborate an underpinning ‘theory of simulation.” As well as establishing the scientific basis of our field, this will

> provide insight into the theoretical frameworks of related disciplines, helping learners and teachers to select the type of simulation which best meets their needs at a given moment…Without a coherent theory, it is easy to get lost in a confusion of beguiling but disparate fields. (p. 160)

The following section of the literature review will investigate current thinking in learning theories that may help provide a basis on why simulation is an effective tool. A broad spectrum of learning theories is presented with each theory having the potential to influence creation of an integrated simulation learning theory. While this section does provide some examples of how these theories have applicability in simulation, a more unified presentation of a simulation learning theory that draws upon these viewpoints will be presented in Chapter Five.

Within the healthcare simulation literature, Bradley & Postlethwaite (2003b) provided one of the better overviews of learning theories and their influence on patient simulation. The authors noted that issues related to deficits in the research literature prompted their review:

> …there has been criticism of medical education from within the profession of the relative paucity of sound educational research that underpins much of medical education innovation. Medical simulation offers tremendous opportunities for the advancement of our understanding of learning because it is consistent with different ways of conceptualizing learning, and because research in very different paradigms can be accommodated. (p. 1)

Dunn (2004) supplied another overview in the simulation literature that briefly reviewed five leading educational theoretical viewpoints: behaviorist, cognitivist, humanist, social learning, and constructivist. In his introduction, he cited this proposition:

> Two underlying hypotheses must be recognized in the context of reviewing education theory relevant to critical care instruction. The first of these is that better learning is associated with improved teaching techniques. The second is that education as a discipline (similar to research and practice domains) has its own tool set (i.e., the knowledge-of-education theory) which, if well applied and adequately studied, can facilitate learner (and perhaps patient) outcomes. (p. 15)

Several education theories and models have been suggested as a means of explaining simulation’s effectiveness. Other potentially relevant theories have not been tied directly to manikin-based patient simulation, but deserve investigation. Among the theories and models discussed in the simulation literature are constructivism, experiential learning theory, adult learning theory, and the novice to expert continuum. Other education theories and models that hold potential in explaining why simulation works include brain-based learning and social cognitive theory.

Constructivism

Constructivism includes several different theories and points of view (Fenwick, 2000; Woolfolk, 2004). Woolfolk cited the influences on constructivist thought to educational theorists and philosophers including John Dewey, Jean Piaget, Lev Vygotsky, and Jerome Brunner. Constructivism places the learner in an active role rebuilding their knowledge based on new experiences.

Delgarno (2001) cited three major principles that guide constructivist learning:

- Each person has his or her own unique experience and knowledge. Delagarno traces this principle from Kant, through Dewey, and most recently to von Glasserfield.
- Learning occurs through active exploration when an individual's knowledge does not fit the current experience. In Piagetian terms, this would be disequilibrium. Using Vygotsky's terminology, this is the zone of proximal development.
- Learning requires interaction within a social context. Referring to Vygotsky, Delgarno stated that this social context is integral to learning.

Fenwick (2000) provided these insights in her definition of constructivism:

> The learner reflects on lived experience and then interprets and generalizes this experience to form mental structures. These structures are knowledge, stored in memory as concepts that can be represented, expressed, and transferred to new situations…A learner is believed to construct, through reflection, a personal understanding of relevant structures of meaning derived from his or her action in the world. (para 18 & 19)

Within constructivism there are many viewpoints and there are conflicts related to just how information should be presented. Dalgarno (2001) made these observations:

> Radical constructivists claim that learners should be placed within the environment they are learning about and construct their own mental model, with only limited support provided by a teacher or facilitator. More moderate constructivists claim that formal instruction is still appropriate, but that learners should then engage in thought oriented activities to allow them to apply and

generalise the information and concepts provided in order to construct their own model of the knowledge. Adding a third dimension is the view that knowledge construction occurs within an environment that allows collaboration between learners, their peers, experts in the field, and teachers. (p. 184-185)

One concept from the constructivist viewpoint that is particularly relevant to patient simulation is the concept of situated learning. As Woolfolk explained, situated learning is “the idea that skills and knowledge are tied to the situation in which they were learned and difficult to apply in new settings (2004, p. 326).” Maudsley and Strivens (2000) commented on situated learning saying, “This perspective claims that ‘learning to do (closely related to knowing how) takes place through solving problems in context (p. 537).” Simulation offers several advantages aimed at overcoming the specificity of the learning context. First, in simulation-based education, the knowledge or skills are presented in context as opposed to being presented in an environment that may not have a real-world implication. Second, simulation-based education emphasizes the function of debriefing after a simulation. This provides the opportunity to review the situation and examine what other contexts the knowledge and skills may be applied. Lastly, through the reflective process of debriefing, simulation-based education instills a critical thought process in the learner that better prepares the learner to transition the knowledge and skills into new situations.

The idea of context is a central concept in constructivist thought. Instead of introducing knowledge and skills in a simplistic manner in a noncontextual environment, constructivism would advocate the use of complex learning environments that mimic the real-world application of the knowledge and skills. This is best represented by Gaba and

Small’s (1997) “full environment” simulation. Here the complex problems associated with the new knowledge or skill are embedded into real-world authentic tasks. Complex learning environment emphasize the ambiguity of many real-world situations and force learners to integrate previous knowledge to the new situation.

Beaubien and Baker (2004) made the recommendation that full mission simulation be conducted with scenarios that generate “ambiguity, time pressure, and stress (p. i54).” In their recommendation, they also suggest another constructivist strategy – the use of scaffolding to help learners progress from one level to the next. This technique is credited to Jerome Brunner (Woolfolk, 2004). Scaffolding involves the teacher or facilitator (or as Beaubien and Baker suggested, an experienced clinician) being involved in the scenario to offer support to the less experienced learners. This support is not directive. The aim with scaffolding is to guide the learner towards the correct response, allowing the learner to make the discoveries. Kneebone (2005) pointed out the problem of providing too much feedback during scaffolding. As Kneebone described, once the learner reaches a level where performance is internalized, additional feedback may become counterproductive.

Kneebone, Scott, Darzi, and Horrocks (2004) discussed Vygotsky’s zone of proximal development and scaffolding. They saw the zone of proximal development (ZPD) as being a particularly well-suited concept for task-based simulation. According to Kneebone, Scott, Darzi, and Horrocks, many elements of the ZPD are present in simulation-based training: the ability to work individually or in a small group or team, the presence of an expert resource in the form of the facilitator or other more experienced and knowledgeable team members, a nurturing and positive leaning environment, instructor support adjusted to the level of expertise of the student, and guided feedback

Another key point of constructivism is that it forces the ownership of learning onto the learner (Woolfolk, 2004). While the teacher still plays a vital role in the education process, the learner plays a more active part as he or she is the only one who can relate his or her own unique personal knowledge history into the current situation.

The role of the teacher in simulation has some difficulties, or at least potential problems that must be addressed. Kneebone, Scott, Darzi, and Horrocks (2004) stated, “Each person’s learning trajectory is unique. Past experience, natural aptitude, motivation, and many other variables combine with contextual barriers and triggers to create a shifting pattern of process and progress in learning (p. 1099).” Burnard (1987) pointed out two problems. First, every learner brings a unique personal experience into the simulation. It is not possible for the teacher to know this experience. Therefore, some actions that may seem logical on the part of the learner based on that personal experience may not be appreciated by the teacher. Second, with each person in the simulation (both learners and teachers) having his or her own personal experience, some form of consensus reality must be shaped in order to apply the new knowledge. Burnard mentions the problem of “multiple realities” that must be fused together to make a meaningful learning experience for all involved.

Peters (2000) explained this further, stating, “In essence, constructivist teaching is mediation. A constructivist teacher works as the interface between curriculum and student to bring the two together in a way that is meaningful to the learner (p. 167).” He continued:

> The idea that students discover and construct meaning from their environment suggests a rethinking about how they could teach. A constructivist teacher is one who designs learning experiences that are active, where the learners are "doing," reflecting on and evaluating their learning experiences, and building on previous learning experiences to construct new knowledge and meaning (p. 167-168)

Experiential Learning and Reflective Thought

Beaubien and Baker (2004) commented, "There is an old saying that 'practice makes perfect'. In reality, practice makes behavior more or less permanent. Perfection can only be achieved through practice with feedback (p. i55)." Through practice (simulation) and feedback (debriefing) learners have the best opportunity for reaching that perfection. One educational theory that embraces this concept (or at least has been embraced by the simulation community) is experiential learning theory.

Experiential learning is a frequently mentioned subject in both the medical and general simulation literature (D. Alverson et al., 2005; D. C. Alverson et al., 2004; Cleave-Hogg & Morgan, 2002; Fallacaro, 2000; J. A. Gordon, Oriol, & Cooper, 2004; Hanna & Fins, 2006; Kneebone, 2003; Kneebone & ApSimon, 2001; Leigh & Spindler, 2004; Makoul, 2006; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005; Morgan, Cleave-Hogg, Desousa, & Lam-McCulloch, 2006; Morgan, Cleave-Hogg, McIlroy, & Devitt, 2002; Watterson, Flanagan, Donovan, & Robinson, 2000; Wilson, Shepherd, Kelly, & Pitzner, 2005). The basis for much thought on why experiential learning in patient simulation is a viable educational tool can be related to John Dewey. As Hammond (2004) summarized from Dewey's 1938 book *Experience and Education*, Dewey "outlined four key concepts of learning: experience, democracy, continuity, and interaction. His premise was that education took place through interplay between objective and internal conditions, and that 'all genuine education comes through experience.' Expertise can only be gained by sustained practice over a period of time (p. 235)." Hytten (2000) noted, "Dewey's attitude toward education…is an experiential one. As a pragmatist, he wants us to test out our ideas in practice, so that we can see their consequences in action and modify them in order to bring about better results (p. 459)." She also discussed Dewey's Laboratory School as a place where teachers could experiment with new ideas and see concepts put into practice. While real teaching with real students took place in Dewey's school, one could say the Laboratory School was a highly complex full-environment simulator.

Burnard (1987) discussed three domains of knowledge: propositional knowledge, practical knowledge, and experiential knowledge. While each domain can remain isolated, knowledge is enhanced when there is overlap between the domains and is most effective when all three domains overlap. Propositional knowledge is facts, theories, and models – what Burnard describes as "textbook" knowledge. Practical knowledge is knowledge in action; it is knowing how to do something, whether it is a psychomotor skills or a mental process (such as conducting a patient interview). Experiential knowledge requires a greater personal relationship with the material to be known. Experiential knowledge adds another dimension to the material or subject that makes for a more complete knowledge. Translating Burnard's thoughts into the simulation arena, experiential knowledge would be related to the metacognitive abilities of the students. It also requires reflection in order to build on the experience. Burnard referred to the works of Pablo Freire and the concept of praxis. As defined by Freire, praxis is "reflection and action upon the world in order to transform it (Freire, 2003, p. 51).” This concept of reflection as a means of improving performance is a oft repeated item in the simulation literature (Bond et al., 2004; Dannefer & Henson, 2004; Flanagan, Nestel, & Joseph, 2004; J. A. Gordon, Oriol, & Cooper, 2004; Kneebone et al., 2002; McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005; S. W. Roberts & McCowan, 2004; Watterson, Flanagan, Donovan, & Robinson, 2000).

The concept of reflection on experience as a means of improving knowledge and performance is not a new concept to education in general. John Dewey made these observations about experience and reflection in 1916:

> When we experience something we act upon it, we do something with it; then we suffer or undergo the consequences. We do something to the thing and then it does something to us in return; such is the peculiar combination. The connection of these two phases of experience measures the fruitfulness or value of the experience. Mere activity does not constitute experience…Experience as trying involves change, but change is meaningless transition unless it is consciously connected with the return wave of consequences which flow from it. When an activity is continued *into* the undergoing of consequences, when the change made by action is reflected back into change made in us, the mere flux is loaded with significance. We learn something. (Dewey, 1916, p. 139)

Experiential learning is more than just “learning by doing.” To meet the modern definition of experiential learning, some action must take place after the experience to create a more integrated meaning for the knowledge gained from the experience. J. Roberts (2002) commented:

> We must move beyond mere "learning by doing" for our fields' philosophical underpinnings and practical approaches to become more influential in mainstream education. Using only the learning by doing definition, experiential education becomes nothing more than activities and events with little to no significance beyond the initial experience…This was not John Dewey's vision and it cannot be our lasting legacy (p. 264)

Dewey (1916) saw a significant difference between trial-and-error experience and the use of reflective thought:

> No experience having a meaning is possible without some element of thought. But we may contrast two types of experience according to the proportion of reflection found in them. All our experiences have a phase of "cut and try" in them – what psychologists call the method of trial and error. We simply do something, and when it fails, we do something else, and keep on trying till we hit upon something that works, and then we adopt that method as a rule of thumb measure in subsequent procedure…We see *that* a certain way of acting and a certain consequence are connected, but we do not see how they are…In other cases we push our observation farther. We analyze to see just what lies between so as to bind together cause and effect, activity and consequence. This extension of out insight makes foresight more accurate and comprehensive. (p. 145)

Without reflection simulation becomes simply a behavioristic response, or, as Dewey stated, trial and error learning. It is this practice of connecting cause and effect that makes simulation with a subsequent debriefing an effective learning method.

Experiential learning has many connections with constructivism (Quay, 2003). One concept that demonstrated this is the idea that traditional roles in the learning dyad (teacher and student) change substantially. Leigh and Spindler (2004) made this observation:

> Traditional approaches position the educator in control of learning with final authority over content and learning processes…In contrast, experiential learning positions the educator in a supportive role and locates the learner at the center of the process. From this position, the educator helps identify opportunities for learning, engages the learner in dialogue with these, and relinquishes authority to direct the learning process….These two positions – traditional teaching and experiential facilitation – require quite different, and at times contradictory, skills and processes. (p. 53)

Of all the experiential education models presented, it is the work of David Kolb that has clearly taken center stage in the simulation literature. Kolb is mentioned often in the simulation literature (Cleave-Hogg & Morgan, 2002; Flanagan, Nestel, & Joseph, 2004; Maudsley & Strivens, 2000). Kolb cited several theorists and educators as his primary influence in creating experiential learning theory (ELT). These primary influences included John Dewey, Kurt Lewin, and Jean Piaget. He credits secondary influences to Carl Jung, Erik Erikson, Carl Rogers, Abraham Maslow, and the gestalt theorists including Fritz Perls (D. A. Kolb, 1983).

Kolb's model lends itself well to simulation. As Cleave-Hogg and Morgan (2002) stated, "Kolb and others maintain that professional education can be improved if students are challenged by active engagement in the learning process that replicates real situations as closely as possible (p. 23).” This recommendation is made to order for patient simulation.

Kolb defined learning as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience (D. A. Kolb, 1983, p. 41).” Kolb’s ELT is frequently represented as a learning cycle with four stages: Concrete experience, observation and reflection, formation of abstract concepts and generalizations, and testing implications of concepts in new situations. However, Kolb (D. A. Kolb, 1983) stated this learning cycle is actually credited to Lewin (see Figure 1). Kolb used Lewin’s experiential learning model as a base to build his ELT model (see Figure 2).

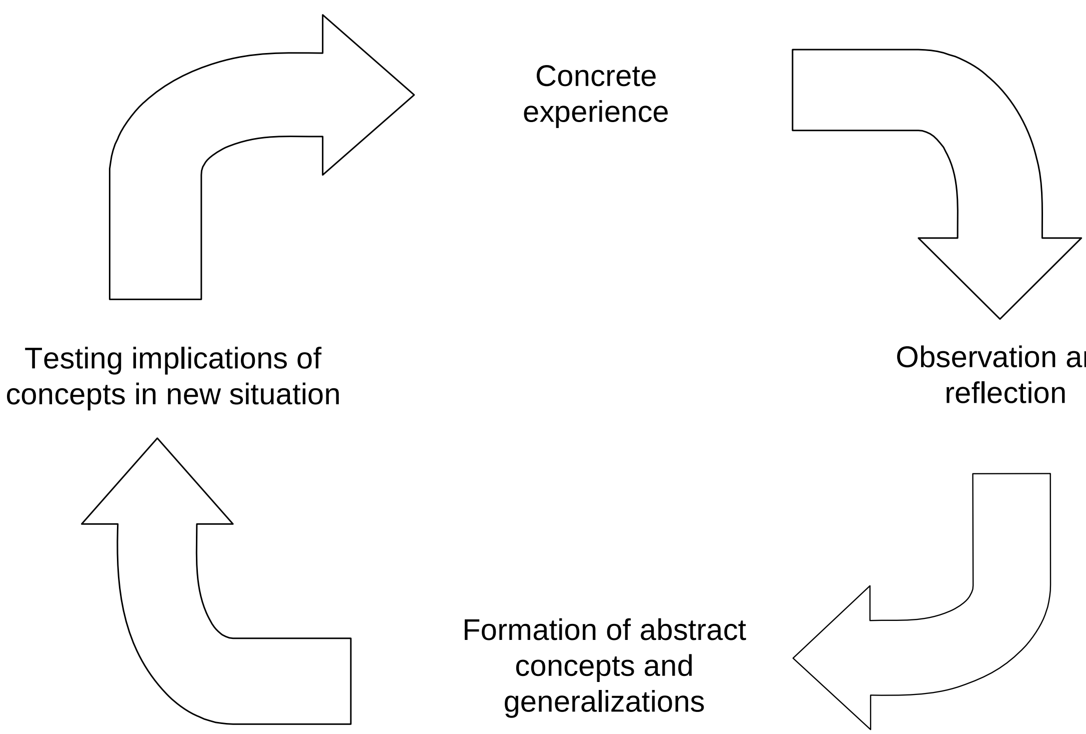

Figure 1. A representation of Lewinian experiential learning model (adapted from Kolb, 1983)

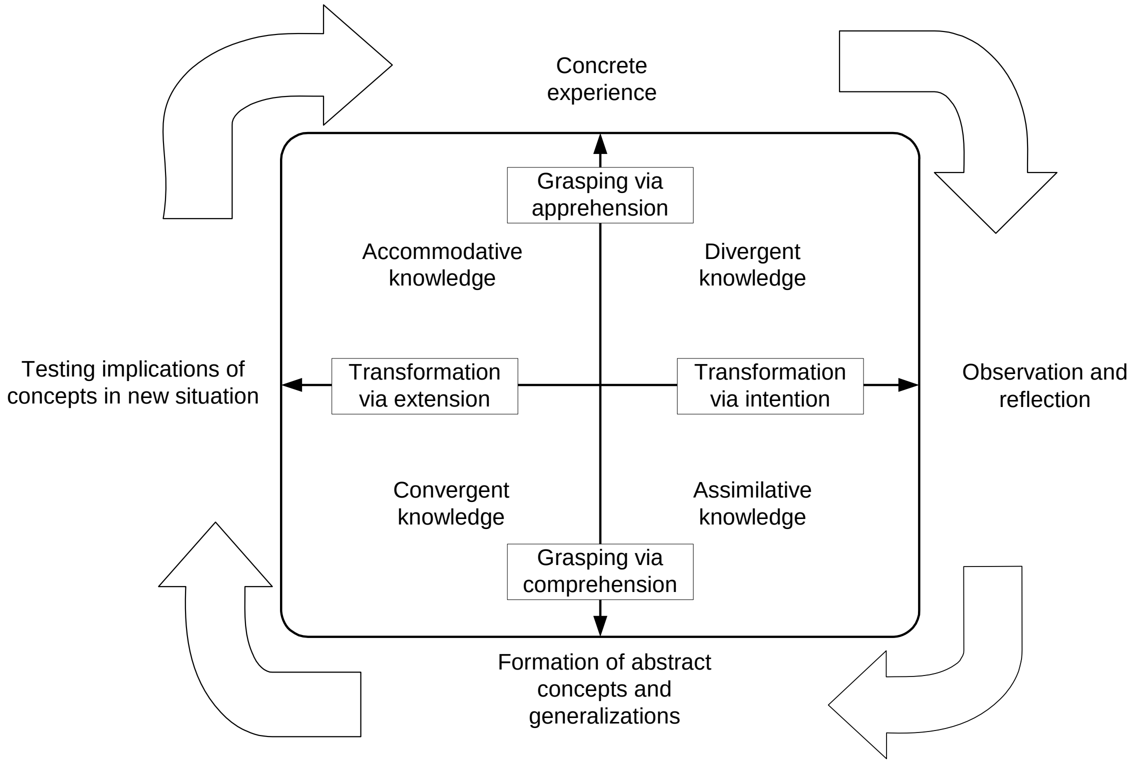

Figure 2. A representation of Kolb's experiential learning model structural dimensions overlayed on Lewinian experiential learning model (adapted from Kolb, 1983)

Lewin's model contains the key features that are most commonly referred to in the simulation literature. Lewin's model is primarily a feedback loop where the learner undergoes a concrete experience (the simulation) and then receives feedback (either in the form of simulator response to interventions or through a reflective debriefing process). As Kolb noted, "This information feedback provides the basis for a continuous process of goal-directed action and evaluation of the consequences of that action (p. 22)." Within this model, learning becomes a process rather than an outcome.

Kolb added additional dimensions to Lewin's model. Kolb bisected Lewin's model with two additional lines. First was a line depicting the "grasping" of knowledge either through apprehension (concrete experience) or through comprehension (abstract conceptualization). Second was a line depicting the “transformation” of knowledge through intention (reflective observation) or through extension (active experimentation).

Grasping via apprehension means being aware of the experience without much thought. It is simply a mater of experiencing the experience. Grasping via comprehension means being cognitively aware of the experience. Transformation via intention is an integrative step between apprehension and comprehension where the learner internalizes the experience and makes attributions that lead to an understanding of the implications of the experience. Transformation via extension externalizes the understanding so that it can be applied in new situations.

Once separated into quadrants, Kolb inserted four learning styles: divergent, assimilative, convergent, and accommodative. Kolb summarized these learning styles (D. A. Kolb, 1983):

- The *convergent* learning style relies primarily on the dominant learning abilities of abstract conceptualization and active experimentation. The greatest strength of this approach lies in problem solving, decision making, and the practical application of idea.
- The *divergent* learning style has the opposite learning strengths from convergence, emphasizing concrete experience and reflective observation. The greatest strength of this orientation lies in imaginative ability and awareness of meaning and value.

- In *assimilation*, the dominant learning abilities are abstract conceptualization and reflective observation. The greatest strength of this orientation lies in inductive reasoning and the ability to create theoretical models.
- The *accommodative* learning style has the opposite strengths from assimilation, emphasizing concrete experience and active experimentation. The greatest strength of this orientation lies in doing things, in carrying out plans and tasks, and getting involved in new experiences. (p. 77-78)

Kolb and colleagues used this model to develope a learning style inventory assessment to identify individual learning styles (A. Kolb & Kolb, 2005).

Kolb's primary influence on simulation has been through his presentation and modification of Lewin's learning cycle model and the detailed background in the roots of experiential learning that he provided in *Experiential Learning: Experience as the Source of Learning and Development* (D. A. Kolb, 1983). Experiential learning using the models presented by Kolb lends itself well to patient simulation.

Adult Learning Theory

Healthcare provider students are adults. As such, adult learning theory plays an important role in patient simulation and is mentioned often in the simulation literature (Cavanagh, 1990; Feingold, Calaluce, & Kallen, 2004; Greenberg, Loyd, & Wesley, 2002; Kneebone, 2002; Maudsley & Strivens, 2000; Yaeger et al., 2004).

Malcolm Knowles is often associated with adult learning theory. However, as Knowles himself described, the lineage of adult learning theory predates his contributions (Knowles, Holton, & Swanson, 1998). The basic tenets of adult education can be traced back to John Dewey. Dewey's influence on adult education is significant because of his association with a contemporary at Columbia University – Eduard Lindemann. Lindemann based many of his thoughts on adult education on principles promoted by Dewey. Dewey and Lindemann shared a common philosophy toward education. Lindemann took many of Dewey's ideas and adapted them to the adult learning. Additionally, Lindeman took concepts and practices from his native Denmark (such as study circles) and incorporated them into his learning theory.

Knowles credits Lindemann as a major influence in the development adult learning theory. Much of Knowles work can trace its origins to Lindemann. Knowles (Knowles, Holton, & Swanson, 1998) cited several passages from Lindemann's 1926 work *The Meaning of Adult Education*:

- The resource of highest value in adult education is the learner's experience. If education is life, then life is also education. Too much learning consists of vicarious substitutions of someone else's experience and knowledge…Experience is the adult learner's living textbook. (p. 37)
- Authoritative teaching, examinations which preclude original thinking, rigid pedagogical formulae – all these have no place in adult education…Small groups of aspiring adults who desire to keep their minds fresh and vigorous, who begin to learn by confronting pertinent situations, who dig down into the reservoirs of their experience before resorting to texts and secondary facts, who are led in the discussion by teachers who are also searchers after wisdom and not oracles; this constitutes the setting for adult education. (p. 37-38)

Heavily influenced by the work of Lindemann, Knowles developed the concept of andragogy as being the science of teaching adults. In his andragogical model, Knowles highlighted six assumptions that made andragogy different from pedagogy. Each principle can be demonstrated in patient simulation education (Knowles, Holton, & Swanson, 1998).

Adults have an intrinsic need to know – Adults need to know why they need to know something. In patient simulation, one of the roles of the facilitator is to set the stage for learning. The realism of high-fidelity manikin-based patient simulation helps establish a need to know as it presents knowledge in context. Learners quickly find out what they do not know in highly complex high-fidelity simulations. Knowles observed, "Even more potent tools for raising the level of awareness of the need to know are real or simulated experiences in which the learners discover for themselves the gaps between where they are now and where they want to be (Knowles, Holton, & Swanson, 1998, p. 65)."

Adults have self-responsibility – There is a desire among adult learners to demonstrate that they are self-responsible and self-directed. Simulation puts control of the learning process into the hands of the learner as each learner actively participates in the learning process. Knowles stated learners must make "the transition from dependent to self-directed learners (Knowles, Holton, & Swanson, 1998, p. 65)." The self-directed nature of patient simulation is a common reference in the simulation literature (Issenberg, McGaghie et al., 1999; Kneebone, 2002; Kneebone & ApSimon, 2001)

Adults have a lifetime of experiences – Life experiences differ greatly in quantity and quality for the adult learner. As a result, adults will be a heterogeneous group and will require a higher degree of individualization. Adult learners can often be their own resources because of their experiences. Sometimes their experience is good; sometimes it is not. Facilitators of patient simulation must be aware of the unique personal knowledge their learners bring with them and be ready to reinforce or discourage behaviors as appropriate.

Adults have an innate readiness to learn – Once a situation is presented in which the adult learner realizes they need more knowledge; there is a readiness to learn. The key is to not present information until that learner has the need for the information. Simulation allows for events to unfold naturally and creates the situation where the learner must respond. Also, in simulation, the learner can be presented with challenges that are not possible in real life. In scenarios such as this, the learner is ready to move from one developmental stage to the next. It is here in Vygotsky's zone of proximal development where facilitator techniques such as scaffolding can be employed to take advantage of the learner's desire to move to the next level. Again, simulation comes up as a topic with Knowles, as he said, "There are ways to induce readiness through exposure to models of superior performance, career counseling, simulation exercises, and other techniques (Knowles, Holton, & Swanson, 1998, p. 67)

Adults have a life-centered orientation to learning – Learning must show a relevance to every-day life. It cannot be subject-centered (as it often is in pedagogy). Problems must have real world application. Simulation encourages bringing real problems to the learning environment. Feingold, Calaluce, and Kallen (2004) cited Knowles as an influence in stating, "clinical simulation…relates to real clinical problems (p. 157)." Halamek et al (2000) wrote the most successful simulations reflect real-life events.

Adults have internal motivators – Adults are more responsive to internal motivators rather than extrinsic factors. A goal of adult education is to remove barriers that threaten internal motivators. One barrier that is mentioned in the patient simulation literature is the idea of a safe debriefing environment that does not threaten the learner. Typically referred to in the literature as a nonjudgmental debriefing, there have recently been alternate approaches proposed that allow facilitators to bring errors to the surface in discussion while still maintaining a positive learning environment for the participants (Rudolph, Simon, Dufresne, & Raemer, 2006).

As Knowles developed his theory, he drew upon other forms of education theory, namely constructivist and humanistic theories. According to Peters (2000), adult learning theory and constructivist thought share many common points, and have, as he describes, a "natural affinity." As he stated, quoting Candy (1989):

> The link between the two appears to be one of symbiosis. Indeed, Candy stated that "constructivism is particularly congruent with the notion of self-direction in emphasizing active enquiry, independence in the learning task, and individuality in constructing meaning"…the implicit links between adult learning and constructivism indicate that constructivism may have an important role to play to play in adult education and research. (168)

The Novice to Expert Continuum

"Novices develop into experts by incrementally acquiring skills that depend on accruing experience," stated Maudsley and Strivens (2000, p. 539). As they further described, there is an ever changing set of rules that govern performance with these rules changing as experience is gained. Cavanagh (1990) summarized the work of Benner

(1984) in explaining the novice to expert continuum as it related to nursing. Novices function with a set of rules that are context-free. Most of their knowledge is, as Burnard (1987) described, propositional or textbook knowledge. When presented with new situations, novices tend to be restricted in their behavior, creating both “limited and inflexible” responses (Burnard, 1987, p. 43). Experts on the other hand, have more context and are less bound by rules. There is a higher degree of perceptional awareness of the situation, what Cavanagh calls a “gestalt” where the whole of the situation is more easily perceived and individual actions are initiated from deducing what is needed from examining the whole. Simulation lends itself well to defining where individual healthcare providers are on the novice to expert continuum. With its replication capability, simulation can be used as a measuring stick for defining where each provider stacks up in caparison to others or can track one learner’s progress over time.

High-fidelity manikin-based patient simulation has been used extensively in testing of students’ ability to meet learning objectives. Devitt, Kurrek, Cohen, and Cleave- Hogg (2001) demonstrated the construct validity of using patient simulation as an evaluation tool. In their study, they reviewed the ability of a group of 142 physicians and students with a wide range of experience (from practicing anesthesiologist to final-year medical students) in their ability to manage a simulated anesthesia case. Their scoring mechanism was able to discriminate between expert and novice user. This approach has been used in several other patient simulation studies to gauge novice versus expert performance (DeAnda & Gaba, 1991; Delson, Koussa, Hastings, & Weinger, 2003; Gisondi, Smith-Coggins, Harter, Soltysik, & Yarnold, 2004; Larew, Lessans, Spunt, Foster, & Covington, 2006; Moorthy, Smith, Brown, Bann, & Darzi, 2003; Morgan & Cleave-Hogg, 2002; Pittini et al., 2002; Pugh, 2001)

While Benner is frequently cited in the healthcare simulation literature, especially in regards to nursing simulation (Benner, 1984; Detty Oswaks, 2002; Larew, Lessans, Spunt, Foster, & Covington, 2006; C. Martin, 2002), Benner's work is based on the model first proposed by Dreyfus and Dreyfus (H. L. Dreyfus & Dreyfus, 1986; S. E. Dreyfus & Dreyfus, 1980). The Dreyfus model of skill acquisition contains five levels:

- Stage 1 – Novice: At this stage facts and skills are understood only in a context free manner. The learner may know how to put an oxygen mask on a patient, but does not fully understand the reasons for doing so.
- Stage 2 – Advanced beginner: The learner at this level begins to become situationally aware and see how facts and skills learned earlier may be adopted in certain situations, The rules for this integration are rather simplistic and complex problems are not yet able to be solved. In a simulation example, the learner may now know that the patient is having respiratory distress and requires oxygen, but fails to understand the complicating factors that affect the oxygen delivery such as the presence of chronic obstructive pulmonary disease.
- Stage 3 – Competence: Through experience, a hierarchical process of decision-making is developed. Prioritization is possible. In the medical simulation this would be seen during the assessment of a trauma victim as the practitioner may quickly move past a seemingly spectacular injury that is superficial to treat a less noticeable, but life threatening condition.

- Stage 4 – Proficiency: Up to this point, decision-making is primarily rule-based. At this level, intuition develops and the practitioner begins to anticipate. Rules still play an important part for the proficient provider, but they are modified based on experience.
- Stage 5 – Expertise: Conscious thought about actions disappears. The expert practitioner simply does what is needed, able to unconsciously appraise the situation and make intuitive actions without regard for thinking through rules. As Dreyfus and Dreyfus (1986) stated, "An expert generally knows what to do based on mature and practiced understanding (p. 30)."

In their original report, Dreyfus and Dreyfus (1980) also referred to a mastery level in which the expert performer goes beyond mere expert performance. They stated,

> The expert is capable of experiencing moments of intense absorption in his work, during which his performance transcends even its usual high level…we note that this masterful performance only takes place when the expert, who no longer needs principles, can cease to pay conscious attention to his performance and can let all the mental energy previously used in monitoring his performance go into producing almost instantaneously the appropriate perspective and its associated action. (p. 14)

In Schon's (1983) description, this is the point of professional artistry.

As summarized by King and Appleton (1997), intuition was a significant factor that distinguished expert nurses from novice and advanced beginner nurses, although some levels of intuition were present in all levels of skill acquisition. With intuition, healthcare practitioners are able to move beyond simple problem identification and grasp a larger sense of the situation, much in the same manner as Cavanagh's (1990) gestalt. King and Appleton stated, "It must be recognized that intuition occurs in response to knowledge, is a trigger for nursing action and/or reflection and thus has a direct bearing on analytical processes in patient/client care (1997, p. 201)." They also surmised that healthcare education uses a predominantly linear approach to care with very little educational effort focused on using intuition in decision-making. High-fidelity, full-environment simulation could be a remedy for this deficit as it allows for an immersive experience that tests more than just knowledge and clinical skills.

Some authors have noted there is a predictable element present in the ability to identify expert performers – deliberate practice (Issenberg et al., 2002; Issenberg, McGaghie et al., 1999; Kneebone, 1999, 2005; Kneebone & ApSimon, 2001; Wayne et al., 2006). Using sports as an analogy, Issenberg, McGaghie, et al (1999) made these comments concerning deliberate practice:

> The most important identifiable factor separating the elite performer from others is the amount of "deliberate practice." This includes practice undertaken over a long period of time to attain excellence as well as the amount of ongoing effort required to maintain it. Deliberate practice has been defined as the opportunity to tackle "a well-defined task with appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and correction of errors." (p. 862)

Kneebone (2005) elaborated further, "Practice should therefore focus on a well-defined area, be supported by detailed immediate feedback, and provide opportunities for gradual improvement of the same or similar tasks (p. 550)."

As Dreyfus and Dreyfus (1986) stated, just because a person achieves a certain level of expertise does not mean he or she will automatically maintain that level: “Practice is required for maintaining know-how. It can be lost through inactivity (p. 17).” For this reason simulation offers an excellent tool for not only teaching and perfecting new skills but also for maintaining skills. This is especially true for healthcare providers who may have achieved expertise but now are working in areas where practicing what they were expert in is reduced. For example, an anesthesiologist may have become expert at managing a patient with malignant hyperthermia. But, owing to the reduced frequency of seeing this crisis event due to improved anesthesia medications and monitoring, has not had the opportunity to practice the skills needed to quickly respond to this emergent event. When presented with this case, the anesthesiologist may revert back to rule-based decision making rather than the intuitive thought process that guided his or her earlier expertise.

Brain-Based Learning

One of the more recent lines of thought in education theory has been the development of brain-based learning (Caine & Caine, 1991; Jenson, 1996). However, the healthcare simulation literature has not explored this area well despite its potential to impact simulation-based education learning theory. Only one study was identified in this literature search that referenced brain-based learning principles in medical simulation education (Wortock, 2002).

Two of the most prominent researchers in brain-based learning are Renate and Geoffrey Caine. They presented three essential elements for learning and 12 principles for brain/mind learning. The three essential elements are:

- Relaxed alertness – Defined as a state of low threat and high challenge, having the learner in this state creates the ideal emotional state for learning. The learner feels competent, confident, interested, and motivated. The learning environment should not be intimidating or fear producing. Based on the work of MacLean (1973, 1978) in introducing the concept of the triune brain, Caine and Caine pointed out when fear is present in learning there is interference in long-term memory encoding, making lasting learning difficult. Jenson (1996) also stated that when challenge is present, the mind is more engaged and receptive to learning, but when a threat to self is perceived, learning is inhibited. Hart (1983) referred to this as *downshifting*.
- Orchestrated immersion in complex experiences – The teacher creates an immersive learning environment that involves as many learner senses as possible. New experiences are related to old experiences (much in the same manner as in constructivism). This element requires knowledge to go beyond just knowing. Something must be done with the knowledge so the learner can "own" that knowledge. This element also instills a questioning and decision pathway in the learning as the learner explores the new knowledge and becomes an active integrator of the new knowledge.
- Active processing of experience – Performance is self-assessed in the midst of the experience as the learner actively engages the teacher, other learners and utilizes feedback to analyze the situation and make decisions based on how new information is integrated into his or her existing knowledge.

Caine and Caine (1990, 1991, 2006) also presented 12 principles that can be transitioned into the simulation learning environment:

1. All learning engages the entire physiology: Learning involves more than just the brain. The entire person – both in body and mind – is involved in the learning process. Factors such as stress and nutrition will impact an individual's ability to learn. The implications of this in simulation are providing an immersive environment and low stress learning in which the fear of failure is removed. Facilitators should provide a supportive learning environment that engages more than just the brain, but rather includes opportunities for involvement of the whole person and on his or her senses.
2. The brain/mind is social: Humans have a natural urge for social contact. Learning is more effective when learners are engaged in processes that permit relationships that allow them to be recognized and have their contributions acknowledged. The simulation-based CRM training emphasizes social structure and communications.
3. The search for meaning is innate: There is a balance between the learner working with the familiar and searching for new knowledge and can be described as a survival mechanism. In simulation, providing learning in a contextual basis in which the learner is rooted in a familiar environment will enhance the learner's ability to look for new knowledge.
4. The search for meaning occurs through patterning: The brain does not learn isolated facts well. There needs to be some logical connection, or pattern, to previously learned knowledge. The learner is actively searching for these

connections. Simulation offers the opportunity for the learner to recognize patterns where new knowledge can be integrated with previous knowledge.

5. Emotions are critical to patterning: Learning is not a purely cognitive function. Emotions play a significant role in encoding and retrieving information. The realism of simulation allows the learner to associate emotions with certain areas of knowledge, such as when the learner in an obstetrics simulation associates the decreased tone of the fetal heart monitor with an emotional need to react.
6. The brain/mind processes parts and wholes simultaneously: As the learner processes information, he or she is examining information both in parts and in the whole simultaneously. As the learner breaks down the skills of a medical procedure (such as endotracheal intubation), the learner must not only examine each part of the skill, but also keep the end result in focus (in the case of endotracheal intubation, patient ventilation).
7. Learning involves both focused attention and peripheral perception: While focus may be on an individual skill, attention is still be directed to the big picture view of the situation. Simulation provides the opportunity for practice of individual skills while creating a need for monitoring the overall patient condition.
8. Learning is both conscious and unconscious: As individuals learn, they are receiving both overt knowledge and covert knowledge. In overt knowledge, the content of the lesson is managed and transmitted. In covert knowledge, an underlying message is being generated about this knowledge. Covert

knowledge may be intentional on the part of the teacher or may be an unintended consequence. In simulation, presenting information in a positive manner that manages the covert message is important in instilling the appropriate response in the learner. For instance, a vitally important skill must be presented in a manner that conveys that importance to the learner. If the teacher presents it in a nonchalant manner, the learner may encode this information as not being important even if the teacher says it is.

9. There are at least two approaches to memory: There are two sets of memory systems. The spatial memory system and a set of systems for rote learning. In spatial memory, recall just happens. Learners do not have to think about what a tree is; they just know it. Recall is automatic and is improved by novelty. Facts and skills that represent isolated ideas and concepts are not processed through by the spatial memory system. These concepts require some degree of organization to create retrieval systems. Simulation plays a role in this by supplying practice in context to help train the brain to retrieve information needed for the clinical scenario.
10. Learning is developmental: All learners do not progress at the same rate. There are individual differences in which each person falls in a novice to expert continuum. Education programs must recognize this and avoid categorizing all learners in the same group. Simulation can be used as a means to discriminate where learners fall on the novice to expert continuum and if the simulation is scalable in its objectives, the simulation can be adjusted to accommodate the appropriate level for each individual learner.

11. Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and fatigue: When fear – including fear of failure – is present, the brain downshifts into a more primitive function and encoding into long term memory becomes problematic. While some stressors in a realistic simulation session are beneficial and help with encoding, fear is a complicating factor. That is one reason why debriefing sessions are done in a non-punitive manner, so individual learners do not fear being criticized, ridiculed, or embarrassed at the conclusion of the simulation.
12. Each brain is uniquely organized: While constructivism establishes that each person has a unique experience, Caine and Caine stated that each learner also has a unique system for learning. Individual learning styles must be addressed whether it is a relatively simplistic approach such as the VAK learning style set (visual, auditory, kinesthetic) or more complex learning styles sets such as Gardner's multiple intelligences (Gardner, 1983). Simulation invokes a variety of senses as it presents material and as such, it offers multiple ways for the learner to access information.

Complexity is an underlying issue in Caine and Caine's work. They stated, "Brain research establishes and confirms that multiple complex and concrete experiences are essential for meaningful learning and teaching (Caine & Caine, 1991, p. 5)." As they further explained, "content is inseparable from context (p. 5)." In simulation this has great impact as all learning is contextual. Immersion (a word Caine and Caine use) is one means of engrossing the learner in the experience. Simulation is an immersive strategy, especially in full-environment simulations.

Social Cognitive Theory

First presented as social learning theory by Albert Bandura, social cognitive theory expands on the behavioristic model of learning (Woolfolk, 2004). Several components of social cognitive theory have relevance with patient simulation. First is the concept of enactive learning. Different from the simple stimulus and response mechanism of behaviorism, enactive learning proposes that each consequence has a deeper role in learning as the consequence should provide information that will be used by the learner in subsequent actions. Second is the concept of vicarious learning by which people learn through observation. Through both participation and debriefing in patient simulation scenarios, all team members have the ability to watch and analyze the performance of other team members. Gaba (2004b) mentioned this aspect in his review of the dimensions of simulation. In a related concept, vicarious reinforcement is another means by which team members can learn by watching other team members be rewarded for their successes. Practice is a vital factor in social cognitive theory. Practice can be mental rehearsals (in itself a form of simulation) or actual hands-on practice. Through practice, combined with feedback and coaching, performance can be improved.

Motivation

"Motivation is the natural human capacity to direct energy in the pursuit of a goal," according to Wlodkowski (1999, p. 7-8). Motivation is a critical component in teaching. Without it, maintaining attention and interest is difficult (Woolfolk, 2004). Motivation can be intrinsic or extrinsic. Intrinsic motivation is the internal driver that pushes learners to accomplish goals and objectives. Extrinsic motivation is the external influences such as good grades for students or increased pay for practicing clinicians.

Motivation is a complex concept and has been addressed by other authors in detail in the general education literature (Theall, 1999; Woolfolk, 2004). In the medical simulation literature, motivation has been seen as a key topic and is discussed in several studies (Feingold, Calaluce, & Kallen, 2004; J. A. Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Kneebone, 2005; Ravert, 2004)

In general, the medical simulation literature sees high-fidelity simulation as a motivating factor for learners to not only learn more in the session they are currently enrolled, but as a motivating factor for learning more once the course is complete. Through qualitative surveys of students' response to simulation, Cleave-Hogg and Morgan (2002) demonstrated a motivating factor in their study. One student commented, "I learned to integrate various pieces of knowledge into a very realistic scenario. It encouraged me to study and learn more about other scenarios (p. 25)."

While the bulk of the motivation literature concentrates on differentiating between intrinsic and extrinsic motivation, motivation can be represented in another way. Trait and state motivation are terms to describe the focus of the motivation. State motivation – as defined by Rubin, Palmgreen, and Sypher (1994) – is a "temporary condition in which individuals direct high levels of concentration toward the competent completion of a task (p. 343)." They continue, "Whereas trait motivation can be defined as a relatively enduring predisposition towards school or learning, state motivation refers to students' attitudes towards a particular class or subject (p. 343)."

Simulation offers several ways to enhance motivation at all levels. One area is through practice and the ability to achieve success or mastery through the support of teachers or facilitators. Kneebone (2005) suggested that through practice, motivation would be enhanced:

> Perhaps, most important of all, is motivation. Simple repetition of a task is not enough, but must be underpinned by a determination to improve. Such a determination underpins the continual striving toward improvement that is a sine qua non for achieving expertise. (p. 550)

J. A. Gordon, Wilkerson, Shaffer, and Armstrong (2001), commented, “[The medical students] felt that the experience promoted critical thinking and active learning, and that it allowed them to build confidence and practice skills in a supportive environment (p. 472).”

The active role the learner plays in the learning process with simulation also contributes to motivation. Feingold, Calaluce, and Kallen (2004) wrote, “As a teaching strategy, simulated clinical experiences are consistent with adult learning theory. Data indicate that active learning increases motivation and interest in learning (p. 161).” Ravert (2004) had similar conclusion. The simulation-based education group in Ravert’s study indicated a greater degree of motivation to learn more. “The HPS [Human Patient Simulator] group was more enthused about learning and expressed a desire for further sessions. The HPS group said ‘learning by doing’ was helpful and felt more confident in caring for patients (p. iv & v).”

Another area where simulation provides an influence on motivation is in the practice of learning in context. J. MacDonald (1999) pointed out that each discipline has its own learning climate that relates to how it meets its objectives. For some disciplines, that climate may primarily involve cognitive exercises and a traditional classroom format may be well suited to the needs of the learners in performing in the climate. However in healthcare, the eventual climate is at the patient's side. Simulation provides learning in context that allows learners to attribute more significant meaning to what is being learned. By seeing knowledge in action, motivation may be enhanced.

There are several theories behind motivation. As demonstrated in this literature review, cognitive and constructivist theories dominate the literature in medical simulation. As opposed to the behaviorist point of view for motivation that is primarily extrinsically driven, cognitive theory approaches suggest there is a greater degree of intrinsic motivation. Two approaches to motivation that fall in with the cognitive viewpoint are attribution theory and expectancy value theory. In attribution theory there are three dimensions that contribute to success or failure (Woolfolk, 2004). Locus determines if the cause is internal or external to the learner. Stability determines if the cause is stable or can change over time. Controllability is whether the learner has command over the cause. How these dimensions are influenced in simulation-based education is critical to their impact on motivation. Simulation places a significant amount of control of the learning process in the hands of the learner as he or she explores the simulation environment. Through the debriefing process, deficits in knowledge and performance can be identified and corrected in a supportive and nonjudgmental manner. Learners can be placed into the same simulation again and see that improvement is possible.

Expectancy value theory combines the behavioristic viewpoint of reward or expectation with the cognitivist viewpoint of internal valuing (Woolfolk, 2004). For the best potential for motivation, a learner needs to have an expectation for success and that expectation must have a high value (Paulson & Feldman, 1999). There are a variety of motivators in healthcare education. Some are external such as promotions, increases in pay, and decreases in malpractice insurance for practicing healthcare providers. For healthcare students, motivators can be grades or improved opportunity for successful job placement. Some are internal such as the innate desire to learn more and become better practitioners so that patient care can be its best. Simulation offers an opportunity to put learning content into practice and an arena for teachers to instill value in the learners' perceptions of the content.

The manner in which knowledge is presented to the learner has the ability to influence several factors including motivation. In a randomized comparison group posttest study of learners using either lecture, video, or interactive multi-media that included screen-based simulations, Rodgers and Withrow-Thornton (2005) found that the interactive multi-media with screen-based simulations enhanced motivation by providing higher levels of learner attention, relevance, confidence, and satisfaction with the course material. Built on the ARCS model of motivation (Keller, 1987a, 1987b, 1999), the interactivity present in the screen-based interplay between learner and content provided multiple opportunities for learners to build on successes with the interactions and required a continued contact with the material. Manikin-based simulation offers this same opportunity.

Simulation in team-based training offers additional opportunities for improving motivation. Team-based simulation allows cooperative learning to take place as team members share information in a developing simulation scenario. Panitz (1999) reviewed several studies and found that cooperative learning leads to high degrees of motivation in learners as team members work together to achieve goals. This also results in higher degrees of individual learner self-esteem and satisfaction with the learning experience. When cooperative learning is promoted in teams, higher order thinking skills are developed. And, because cooperative learning requires active participation, learning is enhanced as the learners become engrossed in the content. Simulation-based team learning engenders all these possibilities.

Affective Domain

Bloom (Bloom, Engelhart, Frost, Hill, & Krathwohl, 1956; Krathwohl, Bloom, & Bertram, 1973; Woolfolk, 2004) identified three domains for learning. The cognitive domain involves mental skills and concentrates on knowledge. The psychomotor domain involves manual skills and physical manipulation. The affective domain involves emotions, feelings, and attitudes. In simulation-based education, as with education in general, most work concentrates on the cognitive and psychomotor domain. As demonstrated in this literature review, many simulation-based studies focus on written examinations to test cognitive abilities and expert rater scored practical examinations to test psychomotor abilities. Teaching and testing of the affective domain is not common. As B. L. Martin and Briggs (1986) observed, “What has received relatively little attention by instructional technologist and designers is the development of instruction that incorporates affective goals, objectives, and strategies into educational programs and practices (p. xi).” One of the few courses of instruction that included simulation that specifically targeted the affective domain was conducted by L. M. Jacobs et al (2003); however, this course did not use manikin-based simulation.

Affect in learning deals with the learner's attitudes towards the course material and can be represented in his or her feelings, emotions, and behaviors in how the course knowledge is integrated into the learner's daily life. Affect also has a considerable influence on motivation (Paulson & Feldman, 1999). Affect is described by Rubin, Palmgreen, and Sypher (1994):

> Affect is operationalized to include lower-order levels of students' attitudes towards (a) course, (b) subject matter, and (c) instructor, as well as higher-order levels of students' behavioral intentions of, (d) engaging in behaviors taught in the class, and (e) taking additional classes in the subject matter. (p. 81)

B. L. Martin and Briggs (1986) identified several problems explaining why research on the affective domain lags behind the volume of research on the cognitive and psychomotor domains:

> …affective behaviors are difficult to conceptualize and evaluate. Because of this, the most effort and time have gone into thinking about, studying, evaluating, and teaching the cognitive aspects of behavior. Cognitive behaviors are easier to specify, operationalize, and measure than are affective behaviors…The affective domain poses a unique set of problems for educators. First, the definition of the domain and the concepts that compromise it are so broad and often unfocused that all aspects of behaviors not clearly cognitive or psychomotor are lumped together in a category called the affective domain…The definitional problem is further compounded when one looks within and between disciplines for clarification. Some psychologists define affect as a psychological or biological state; educators

> and other psychologists interested in behavior changes define affect as a cognitive type process. (p. 12-13)

As B. L. Martin and Briggs state there are problems with the definition of affect. Beane (1990) concurred with this view, simply stating, “The meaning of affect is still somewhat ambiguous (p. ix).” Still, Beane did offer a definition:

> In sum, we may now define affect as an aspect of human thought and behavior that has a number of constitutive elements. It refers to a broad range of dimensions such as emotion, preference, choice, and feeling. These are based on beliefs, aspirations, attitudes, and appreciations regarding what are desired and desirable in personal development and social relationships. Both of these are connected to thinking or cognition…Finally, affect is connected to behavior as both an antecedent and a consequence. Thus it is both a constitutive aspect of learning and an appropriate object of educational efforts. (p. 6)

Woolfolk (2004) described Bloom’s original work as a continuum that ranges from a low level of affect to a high level of affect. She listed five points along this continuum:

1. Receiving – The ability of the learner to pay attention to the course matter and respect the role of the teacher and other learners.
2. Responding – The learner provides some sort of response to the course material such as asking questions or participating in course discussions.
3. Valuing – The learner begins to make a commitment to the course material and might follow-up after the course with independent reading or additional courses in the subject.

4. Organization – The learner integrates the knowledge into his or her own value system and places a priority on this knowledge.
5. Characterization by value – The learner has internalized the course content and now actively demonstrates the value of the knowledge in his or her actions.

The broader Emergency Cardiovascular Care literature has identified problems with teaching the affective domain. In recent literature reviews conducted for the 2005 consensus conference for International Liaison Committee on Resuscitation 2005 Consensus on Emergency Cardiovascular Care and CPR Science and Treatment Recommendations, several studies were identified that stated individuals who were trained in performing CPR often fail to act when presented with an emergency situation ("Worksheet ID - Are people who are trained in CPR willing to perform it? (Chest compression only) (A)", 2005; "Worksheet ID - Are people who are trained in CPR willing to perform it? (Chest compression only) (B)", 2005). While the skills of ACLS are advanced level skills and the responders typically have a duty to act, there are still issues with assuring the affective domain has been addressed effectively.

Simulation offers new opportunities to address issues such as learning in the affective domain that often cannot be adequately dealt with in the clinical environment. Kneebone (2005) stated that the affective domain is often ignored in traditional teaching. Kneebone added that in the clinical setting, learning is a by-product of patient care. In the clinical setting, patient care is the focus. In simulation, the priorities can be reversed with the learner now being the focus of attention. With the control offered by a simulation-based learning experience, simulation has the potential to enhance the affective aspect of patient care.

Kneebone (2003) referred to Bloom's affective domain by stating, "Attitudes relate to how knowledge and skill are combined in the care of patients. This area includes clinical judgment, decision-making, the values of professional behavior and the range of vital but intangible qualities that go to make up the competent clinician (p. 268)." Kneebone sees simulation as a possible solution to improving attitudes, or affect, in healthcare professionals. Through processes such as teamwork training in simulation, attitudes can be changed or refined.

Kneebone, Scott, Darzi, & Horrocks (2004) stated that the simulation learning environment should reflect a positive attitude as a means of increasing the chances of learners being able to develop the appropriate affective attitudes needed in healthcare. They said that past learning experiences – either positive or negative – exert a "powerful influence' on how learners approach a learning situation.

The regulating body for physician residency programs in the United States is the Accreditation Council for Graduate Medical Education (ACGME). The ACGME has a required competency in professionalism and defines this competency by stating:

> Residents must demonstrate a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population. Residents are expected to:
>
> - demonstrate respect, compassion, and integrity; a responsiveness to the needs of patients and society that supersedes self-interest; accountability to patients,

society, and the profession; and a commitment to excellence and on-going professional development

- demonstrate a commitment to ethical principles pertaining to provision or withholding of clinical care, confidentiality of patient information, informed consent, and business practices
- demonstrate sensitivity and responsiveness to patients' culture, age, gender, and disabilities ("ACGME outcome project", 2006)

The professionalism competency contains several affective behaviors and forces a valuing process. Gisondi, Smith-Coggins, Harter, Soltysik, and Yarnold (2004) conducted a one-shot case study of 27 emergency medicine residents enrolled in a course designed to evaluate professionalism. Through the use of simulation scenarios, Gisondi and colleagues were able to test residents' ability to demonstrate compliance with this competency. While this study did not attempt to provide additional education in meeting the competency, demonstrating the ability to evaluate the competency lends credibility to the concept of teaching it, especially with the use of reflective debriefing processes.

Summary

Upon reviewing the current literature, the following generalizations can be made. As an education program, the American Heart Association Advanced Cardiovascular Life Support course has proved to be an effective education intervention in teaching Emergency Cardiovascular Care knowledge. This has been effectively demonstrated not only in improved learner outcomes, but also in improved patient care and survival.

High-fidelity manikin-based patient simulation has demonstrated a high degree of efficacy in health care provider education. There are many drivers in place that make high-fidelity manikin-based patient simulation a viable alternative option for healthcare provider education and this type of education intervention has proved to be an effective education strategy for teaching many different patient assessment and treatment procedures. Learner perceptions of high-fidelity manikin-based patient simulation have been positive and include high degrees of acceptance, improved learner confidence, and greater levels of learner satisfaction and have been successfully integrated into nursing curriculums with positive results.

While high-fidelity manikin-based patient simulation has shown considerable utility in healthcare provider education, no one learning theory has been identified that directs high-fidelity manikin-based patient simulation. Several learning theories have been promoted as explanations for manikin-based simulation education’s effectiveness, most notable experiential learning theory.

Two important contributors to student success in learning – motivation and learner affect – have only been briefly mentioned in the simulation literature. The general thought on both of these subjects indicates that high-fidelity manikin-based patient simulation should have a positive impact on the learner. These two areas require additional investigation to determine the direction and impact of high-fidelity manikin-based patient simulation on learner motivation and affect.

CHAPTER THREE: RESEARCH METHODS

The purpose of this study was to determine if the use of high-fidelity manikin-based patient simulation improves the educational outcomes of students as compared to the outcomes in students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support course. This study used a quasi-experimental design to compare educational outcomes between the two groups. It was quasi-experimental due to the inability to randomize subjects to groups. All other elements of an experimental model were present. An experimental model was the best means of which to establish a cause and effect between the intervention and outcomes. As described by Vockell and Asher (1995), "An experiment refers to an attempt to establish a cause-and-effect relationship by some strategy such as administering a treatment to one group and withholding it from another…the term is only used when there is manipulation of the subjects (p. 253)." Manipulation was accomplished in this study through the use of different technology interventions.

This study did not have a control group in which no intervention was conducted. Rather, a comparison group received a standard education program in Advanced Cardiovascular Life Support. Vockell and Asher (1995) noted the distinction between the two terms – control group and comparison group:

> The control group is the group of subjects from whom the treatment is withheld or who receive the usual, standard treatment and conditions and who performance is compared with that of the experimental group. A related term is comparison group; the two terms are often used interchangeably. The distinction, when there

is one, is that the control group receives no treatment, whereas a comparison group receives an alternative treatment. (p. 253)

Population and Sample

The population for this study was healthcare providers who may provide Emergency Cardiovascular Care for adults and participate in an Advanced Cardiovascular Life Support course. In 2005, 702,995 individuals completed training in American Heart Association Advanced Cardiovascular Life Support (personal communication, Alan Carrington, American Heart Association, August 4, 2006). The intended sample for this study was a convenience sample of senior nursing students enrolled at any one of four nursing education programs in central and southern West Virginia. Recruitment of subjects was through communication with nursing program directors and faculty at the participating colleges and universities. Due to limitations in physical space, total enrollment was 48 subjects. The first 48 subjects to apply for inclusion in the study were selected.

Senior nursing students from these schools were selected for the following reasons:

1. As seniors in nursing education programs, these individuals would soon be entering the job market. Completion of an ACLS class with subsequent certification card being issued would make each individual more competitive in the marketplace. This would be a motivator to participating in the course.
2. Subjects would possessed the base knowledge needed for entry into the course.
3. All subjects would be of relatively equal knowledge level.

4. None of the subjects should have extensive experience in Emergency Cardiovascular Care.
5. Very few members of this sample will have prior experience with the ACLS program.
6. Very few members of this sample will have had exposure to high-fidelity manikin-based patient simulators.

Due to the naivety of the sample members in content knowledge and simulation technology as well as the comparative lack of experience in Emergency Cardiovascular Care, this sample selection reduced the impact of several potential confounding variables.

The typical cost for participation in this course for this geographic area is $150 per participant. Subjects in this study were not charged for entry into the course. Each participant was informed that he/she would be participating in the course as part of an experimental study evaluating teaching methods. All subjects were unaware as to the specifics of what methods were being investigated. Informed consent was obtained from each participant in accordance with the policies and procedures of the Charleston Area Medical Center Health Education and Research Institute's (CAMC Institute) Institutional Review Board (IRB) and Marshall University IRB. Because of the need to match pretest and posttest scores on the ACLS written evaluation and the need to know which intervention group the subject is assigned, subject anonymity in all areas of this study was not possible. Subjects who successfully completed the ACLS course, including the posttest, received certification in Advanced Cardiovascular Life Support. Therefore, it was necessary to attribute posttest scores with individual subjects. Subject confidentiality was maintained. Subject anonymity was assured in the administration of four of the survey instruments: demographic survey form, participant self-assessment (precourse and postcourse), Affective Learning Scale, and Student Motivation Scale.

Intervention

The intervention for this study was the American Heart Association Advanced Cardiovascular Life Support course. The independent variable was the type of educational technology utilized – with one group receiving ACLS training using high-fidelity manikin-based patient simulators and the other group using low-fidelity manikins. The course was conducted in accordance with the rules and requirements of the American Heart Association Program Administration Manual and in adherence to additional requirements found in the American Heart Association Advanced Cardiovascular Life Support Instructor Manual. Expert ACLS Instructors taught the course.

All components of the two intervention courses were identical with one exception. In one course, high-fidelity manikin-based patient simulators were used with all features of the simulators activated and accessible to the subjects. Subjects had to acquire all clinical information needed for completion of scenarios from the simulator. In the other course, the high-fidelity manikin-based patient simulators were not activated. In an unpowered state, these devices will not function in a high-fidelity manner. They were used as a static, low-fidelity manikin more traditionally used in ACLS courses. Subjects were reliant on obtaining a significant portion of the clinical information needed for the scenario by asking questions of the ACLS Instructor.

One key element in the successful use of high-fidelity manikin-based patient simulation is the debriefing process that follows the practice scenario. In the debriefing, the instructor serves as a facilitator leading the subjects through a reflective process, analyzing actions, and planning for changes in the next scenario in order to improve performance. High-fidelity manikin-based patient simulators come with software built into their programming to aid in this process. The software provides feedback on subject performance to the point of noting either successful completion or failure to meet key learning objectives in the scenarios. The simulator used in this study also had audio/video playback of the scenario linked to the key performance objectives.

Because this study was focused on the impact of simulation technology on learning outcomes, both groups participated in a debriefing process at the conclusion of teaching scenarios. For the high-fidelity manikin-based patient simulator group, this debriefing utilized all the resources available from the simulator. For the low-fidelity manikin group, the debriefing consisted of the ACLS instructor leading the subjects through debriefing sessions without the technology available from the simulator, relying on notes and personal observations. By providing a debriefing opportunity to both groups, it further limited the differences between the groups to the use of technology.

The only difference between the two courses was the use of the simulator technology. All confounding variables were managed by providing an otherwise identical learning experience with all other resources being equal. By doing this, the study was able to focus on the simulator technology as the only variable of consequence.

Instrumentation

Six instrument measures were used. These were:

1. Demographic Survey Form – This self-administered form was used to gather specific demographic information about individual subjects in this study. The Demographic Survey Form is found in Appendix C. Specific questions are:

    Age – Age of the student at the time of taking the ACLS course.

    Gender – Student sex: male or female.

    Nursing Program – Level of nursing school training: Diploma, Associate Degree, or Bachelor of Science in Nursing.

    Prior healthcare experience – Has the student worked in a professional healthcare setting prior to or during their nursing program: Yes or No.

    If answering yes to prior healthcare experience, how many years?

    Prior ACLS Experience – Has the student ever participated in an ACLS course prior to the intervention: Yes or No.

2. ACLS Written Examination – This instrument was used as a written pretest and posttest instrument. There are two versions of the ACLS Written Examination. One version was used as a pretest; the other version was used as a posttest. The ACLS Written Examination is provided by the American Heart Association and is the written evaluation instrument used in all ACLS courses. The ACLS Written Examination was developed by two subcommittees of the American Heart Association national Emergency Cardiovascular Care Committee (Advanced Cardiovascular Life Support Subcommittee and Education Subcommittee) and was validated using a modified Angoff item-based judgment process.

3. ACLS Mega Code Performance Score Sheet (Modified) – This instrument was used as an evaluation tool for subjects' skills at the conclusion of the course and will be completed by expert raters. The ACLS Mega Code Performance Score Sheet is the standard skill evaluation assessment instrument used in all ACLS courses. The ACLS Mega Code Performance Score Sheet was developed by two subcommittees of the American Heart Association national Emergency Cardiovascular Care Committee (Advanced Cardiovascular Life Support Subcommittee and Education Subcommittee). The ACLS Mega Code Performance Score Sheet instrument was tested through a series of pilot courses conducted by the American Heart Association prior to its release as the skill assessment instrument for the ACLS course. It has been modified for use in this study by changing the item responses from Yes/No responses to a range response from 1 being *not competent* to 7 being *highly competent*. Modifications were made by consolidating common objectives from four different ACLS Mega Code Performance Sheets (one each for four different scenarios) to a single document. Additional expert rater responses were solicited on two additional items: overall performance and team functioning. Pilot testing of this modified form was conducted with ACLS course instructors from programs conducted prior to the intervention courses to determine ease of use and clarity. The ACLS Mega Code Performance Score Sheet used in this study is found in Appendix D,
4. Participant Self-Assessment – This instrument was a self-administered written assessment completed by all subjects prior to and at the conclusion of the course. Included on the instrument were quantitative responses regarding confidence in

replicating the skills in a real-world situation. This portion of the instrument is based on the individual skills outlined in the modified ACLS Mega Code Performance Score Sheet. Also included on the posttest version of this assessment were open-ended questions designed to elicit qualitative data in regards to the intervention. The instrument was submitted to a panel of expert Emergency Cardiovascular Care educators to assess readability and content validity. Once content validity was established, pilot testing was conducted with ACLS course participants from programs conducted prior to the intervention courses. The Participant Self-Assessment is found in Appendix E (precourse version) and Appendix F (postcourse version).

5. Affective Learning Scale – This instrument was a self-reported 20-item measure to gauge affect towards learning. Rubin, Palmgreen, and Sypher (1994) reviewed several studies that used the Affective Learning Scale and reported split-half reliability of ranging from .86 to .98. They also reported high construct validity due to its favorable comparisons with other measures of affective learning. The Affective Learning Scale is found in Appendix G. The instrument requires reverse coding prior to summary for certain questions.
6. Student Motivation Scale – This instrument was a self-reported 12-item measure to gauge the impact of course content on motivation. Rubin, Palmgreen, and Sypher (1994) reported on several variations of this instrument designed to measure either trait or state motivation. For the purposes of this study, state motivation is to be measured. The version of the Student Motivation Scale used in this study had reliability coefficients reported from .95 to .96. The Student

Motivation Scale is found in Appendix H. The instrument requires reverse coding prior to summary for certain questions.

Data Analysis

Each instrument produced an overall mean score for its respective group. As there are only two groups in this study – the intervention group and the comparison group – a *t* test was used to determine statistical significance. Significance was set at the $p < 0.05$ level.

In addition to analyzing the overall mean scores for the ACLS Mega Code Performance Score Sheet, analysis at the item level was done to determine if there are differences in individual skills between the two groups. Significance for this analysis was set at the $p < 0.05$ level.

Methods

This study was a quasi-experimental design. Two groups were used – the intervention group and the comparison group. The subjects from the convenience sample were self-assigned into two groups. All subjects were blinded to the group treatments during selection. In order to balance subject participation to equal representation from all participating schools of nursing, a quota assignment was utilized. Each group was to have no more than six subjects assigned from each school. Two groups of 24 were created. One group received the intervention with the high-fidelity manikin-based patient simulators. The other group received the intervention with the manikins operating in a low-fidelity mode. Due to limitations in subject availability, self-assignment was necessary. Randomization – while possible – would have reduced the groups' size. Group homogeneity was managed by the quota assignment and tested through the use of the pretest and initial participant self-assessment.

Each course was conducted separately over two consecutive two-day periods. Experience has shown that once introduced to high-fidelity manikin-based patient simulators, a certain amount of subject excitement is expected. Because many of the subjects come from the same nursing programs and in order to keep the subjects blinded to the use of the simulators during the course, the first intervention group was the lower fidelity manikin group. Low-fidelity manikins are fairly common in nursing education programs. The use of the simulators in this low-fidelity condition did not create an expectation for seeing high technology education devices during the next intervention. Additionally, if the high-fidelity manikin-based patient simulator group were first, talk between subjects may have created an unfulfilled expectation for the low-fidelity simulation group to see a higher degree of education technology employed in their course.

Precourse materials were supplied to the subjects in advance of the course. On arrival to the course, each subject completed the Participant Self-Assessment, Demographic Survey Form, and the ACLS Written Examination as a pre-test tool. The purpose of this pretest is two-fold. First, pretest scores between the groups were compared through the use of a *t* test as a measure to determine homogeneity between the groups in regards to baseline knowledge. Second, the pretest was compared with the posttest to determine if there were any cognitive knowledge differences between the two groups based on the intervention. The study design is depicted in Figure 3.

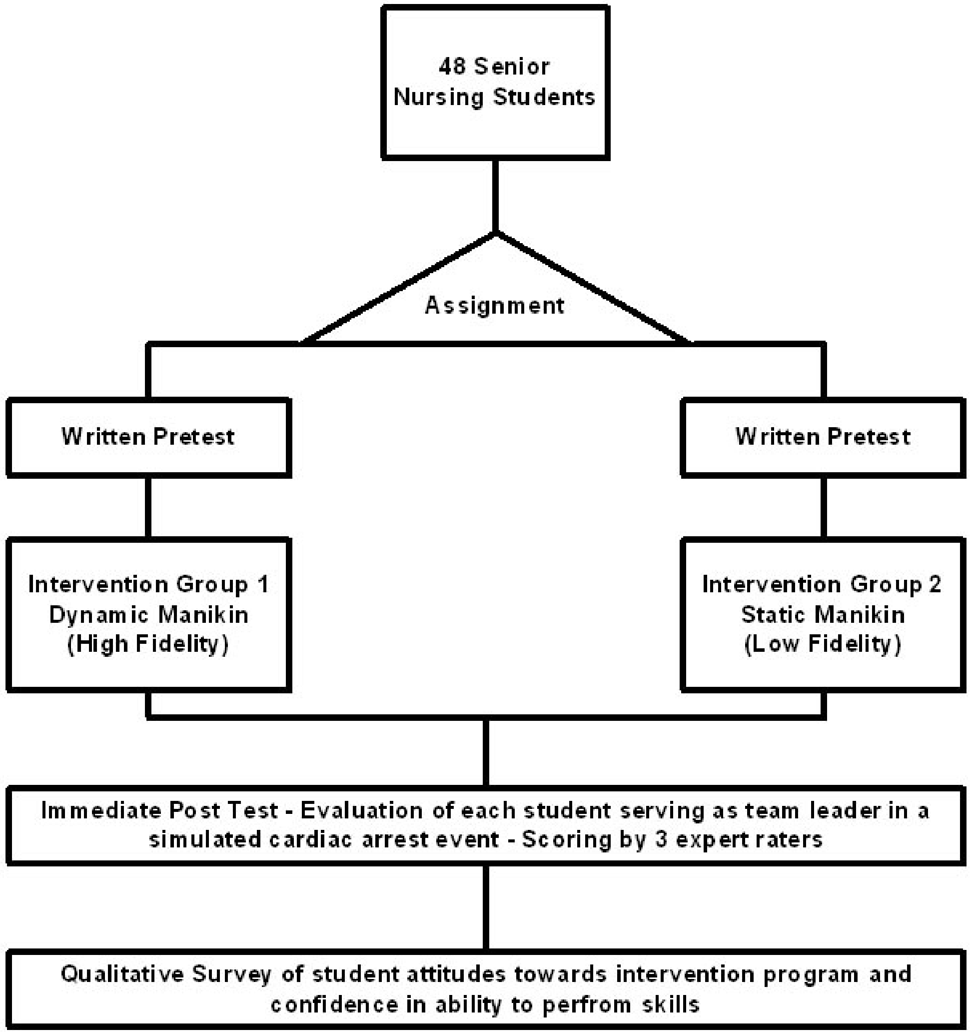

Figure 3. A representation of the study design, showing sample, groups, interventions and measures.

Subjects attended both days of a two-day ACLS Provider Course, defined as the Intervention. After final evaluation scenarios, all subjects had an additional skills performance video recorded. These scenarios were performed with the simulator activated for both groups. This was done in order to allow the expert raters to judge the ability of subjects to transfer the skills to life-like situations. Because the lower-fidelity manikin group did not have experience with the simulator in the activated mode, an orientation to the simulator was conducted prior to this evaluation. The other group had this orientation prior to their first teaching scenario. A panel of three expert raters scored each subject using the modified ACLS Mega Code Performance Score Sheet. Results from the three expert raters were combined to create mean scores for each subject on each item response for the ACLS Mega Code Performance Score Sheet so that each subject has one set of scores to be used in the comparisons. These mean scores were then compiled to produce an overall mean for each group.

After the ACLS Written Evaluation and the final ACLS skills station was completed, subjects then completed the final three self-administered instruments. This included the Participant Self-Assessment, the Student Motivation Scale, and Affective Learning Scale.

Summary

By using a quasi-experimental method and controlling for all known confounding variables, this study isolated the level of educational technology being used (either high-fidelity manikin-based patient simulation or the use of low-fidelity manikins) in order to determine its impact on educational outcomes and student perceptions about preparedness to transfer the skill in real-world situations.

High-fidelity manikin-based patient simulators are expensive educational tools that must be utilized appropriately in order to achieve their full utility. The American Heart Association Advanced Cardiovascular Life course represents the fundamental foundation of advanced Emergency Cardiovascular Care treatment for adult patients experiencing cardiopulmonary emergencies. Determining if the use of high-fidelity manikin-based patient simulators in ACLS is efficacious in regards to improved learning outcomes and greater healthcare provider confidence in performing ECC care will be significant for Training Centers as they determine the best use of their often limited resources.

CHAPTER FOUR: PRESENTATION AND ANALYSIS OF THE DATA

The purpose of this chapter is to present a description of the data collected in this study and to show the results of statistical analysis of the data. The two research hypotheses and the two research questions will be addressed.

Population and Sample

The population of this study was senior nursing students from four area nursing programs. Senior nursing students were chosen because they possessed the basic medical knowledge needed for the course but were relatively naïve to Advanced Cardiovascular Life Support skills. The sample was a convenience sample in which subjects self selected to one of two classes being offered as part of the study. Due to subject scheduling issues, it was not possible to make random assignment of subjects to specific study course dates. Although subjects were able to select their own course dates, subjects were unaware of which intervention was being conducted in their selected course. Target enrollment was 48 subjects with 24 subjects in each study group. A quota system was employed to balance enrollment from the four schools in each study group with six subjects from each school in each study group.

Subject enrollment required modification from the original plan. One target nursing program did not generate enough students to allow for balanced enrollment in accordance with the quota distribution of subjects into the two study groups. As a result, enrollment was limited to three nursing schools with each school enrolling eight subjects in each study group. One subject from the fourth target school was inadvertently enrolled in the low-fidelity manikin group.

Forty-eight subjects were enrolled with 24 subjects in each study group. Actual participation in the study of the program was 37 with 20 in the low-fidelity manikin study group and 17 in the high-fidelity manikin-based simulation study group. There was attrition from the registration list caused by a combination and illnesses and shifting priorities brought about by other school related work forced several students to cancel their participation. Cancellations were so late that additional recruitment for replacements was not possible. Distribution of the subjects according to nursing school for the low-fidelity manikin group was six from school A, six from school B, and seven from school C plus one from the fourth school. Distribution of the subjects according to nursing school for high-fidelity manikin-based simulation group was nine from school A, two from school B, and six from school C.

The low-fidelity manikin group had two subjects who did not complete the program. One subject became ill during the course and withdrew. One subject withdrew due to a family issue. The final *n* for the low-fidelity manikin group was 18. The high-fidelity manikin-based simulation group had one student withdraw due to illness on the morning of the second course day. The final *n* for the high-fidelity manikin-based simulation group was 16. The combined *n* for the study was 34.

A pretest was administered to both study groups to determine knowledge equivalency of the two groups prior to the start of the study courses. The pretest was one of two versions of the ACLS Written Evaluation. The mean score for the low-fidelity manikin group was 72.0 (*SD* = 9.60). The mean score for the high-fidelity manikin-based simulation group was 61.5 (*SD* = 10.82). There was a statistical difference in subjects'

ACLS knowledge prior to the study courses that favored the low-fidelity manikin group, $t(32) = 3.00$, $p = .005$ (two-tailed).

Each group completed the Participant Self-Assessment as a measure of their self-reported confidence with ACLS skills. The mean score for the low-fidelity manikin group was 28.75 ($SD = 8.01$). The mean score for the high-fidelity manikin-based simulation group was 25.53 ($SD = 10.94$). There was no statistical difference in subjects' ACLS confidence prior to the study courses that favored the low-fidelity manikin group, $t(35) = 1.03$, $p = .309$ (two-tailed).

Descriptive Data

Descriptive data were obtained from the Demographic Survey Form. This was a self-administered survey form completed by the subjects at the beginning of the course.

Age

Mean age for the entire sample group was 32.5 ($SD = 9.79$) with a range of 19 to 52. Median age was 30. For the low-fidelity manikin group, the mean age was 31.8 ($SD = 10.46$) with a range of 19 to 52. Median age was 29. For the high-fidelity manikin-based simulation group, mean age was 33.4 ($SD = 9.17$) with a range of 21 to 48. Median age was 34.

Gender

There were 32 females (86.5%) and 5 males (13.5%) in the entire sample group. For the low-fidelity manikin group, there were 17 females (85%) and 3 males (15%). For the high-fidelity manikin-based simulation group, there were 15 females (88.2%) and 2 males (11.8%).

Nursing program

For the entire sample group, there were 15 subjects from bachelor degree programs (40.5%) and 22 from associate degree programs (59.5%). For the low-fidelity manikin group, there were 11 subjects from bachelor degree programs (55%) and 9 (45%) from associate degree programs. For the high-fidelity manikin-based simulation group, there were six subjects from bachelor degree programs (35.3%) and 11 (64.7%) from associate degree programs.

Prior health care experience

For the entire sample group, 19 indicated they had prior health care experience (51.4%). Of those who indicated prior health care experience, the mean number of years of experience was 6.72 (SD = 8.64) with a range of 0.5 to 30. For the low-fidelity manikin group, 10 indicated they had prior health care experience (50%). Of those who indicated prior health care experience, the mean number of years of experience was 7 (SD = 10.69) with a range of 0.5 to 30. For the high-fidelity manikin-based simulation sample group, nine indicated they had prior health care experience (52.9%). Of those who indicated prior health care experience, the mean number of years of experience was 6.44 (SD = 6.65) with a range of 1 to 20.

ACLS Experience

For the entire group, only one subject indicated prior experience with Advanced Cardiovascular Life Support (2.7%). For the low-fidelity manikin group, no subjects indicated they had prior ACLS experience. For the high-fidelity manikin-based simulation sample group, one indicated they had ACLS experience (5.9%).

Major Findings

There were two research hypotheses tested in this study and two research questions that were investigated. Data were analyzed using Statistical Package for Social Science (SPSS) software, Version 14.0.

Hypothesis 1

The first hypothesis stated:

> Students who use high-fidelity manikin-based patient simulators will have better competence as demonstrated in post-intervention skills assessments graded by an expert rater compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

This hypothesis was tested using the ACLS Mega Code Performance Score Sheet (Modified). A panel of three expert raters completed this score sheet while watching audio and video recordings of each group working through a cardiac arrest scenario with patient simulation. Recordings were randomized and the expert raters were blinded to group assignment. Spearman's rho correlation of interrater reliability ranged from .382 ($p < .05$) to .701 ($p < .01$). Correlation data are presented in Table 1

Table 1

Interrater Correlation Coefficients for the ACLS Mega Code Performance Score Sheet (Modified)(N = 34)

	Rater 1	Rater 2	Rater 3
Rater 1			
Spearman's rho	1.000	.701**	.382*
Sig. (2-Tailed)		.000	.026
Rater 2			
Spearman's rho	.701**	1.000	.613**
Sig. (2-Tailed)	.000		.000
Rater 3			
Spearman's rho	.382*	.613**	1.000
Sig. (2-Tailed)	.026	.000	

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The composite mean score for the low-fidelity manikin group was 193.67 (SD = 46.78). The composite mean score for the high-fidelity manikin-based simulation group was 220.88 (SD = 53.23). There was no significant difference between the groups, t(32) = -1.59, p = .122. Hypothesis 1 was not supported. Individual item scores were also calculated and are reported in Table 2. All items showed a higher mean for the simulation group over the low-fidelity manikin group. Seven of the 14 items reported differences that were significant.

Table 2

Individual Item Scores from the ACLS Mega Code Performance Score Sheet (Modified) Between the Low-fidelity manikin (N = 18) and Simulation Group (N=16)

Item	Group	Mean	SD	*t*	*P*
1. The Team Leader assured that	Low-Fidelity	5.02	1.47	-1.58	.116
high-quality CPR was in progress	High-Fidelity	5.50	1.60		
2. The Team Leader assigned	Low-Fidelity	4.81	1.44	-2.20	.030*
team member roles	High-Fidelity	5.40	1.20		
3. The Team Leader assured that	Low-Fidelity	5.20	1.29	-1.62	.109
monitor leads were applied	High-Fidelity	5.60	1.20		
appropriately					
4. The Team Leader assured the	Low-Fidelity	4.68	1.61	-1.056	.293
airway was being managed	High-Fidelity	5.02	1.59		
appropriately					
5. The Team Leader recognized	Low-Fidelity	5.06	1.69	-1.52	.132
the initial ECG rhythm	High-Fidelity	5.56	1.67		
6. The Team Leader properly	Low-Fidelity	5.17	1.55	-.98	.329
utilized defibrillation	High-Fidelity	5.48	1.66		
7. The Team Leader ordered the	Low-Fidelity	4.93	2.05	-1.35	.180
correct medication treatment for	High-Fidelity	5.46	1.91		
the initial rhythm					

Table 2 (Continued)

Individual Item Scores from the ACLS Mega Code Performance Score Sheet (Modified) Between the Low-fidelity manikin (N = 18) and Simulation Group (N=16)

Item	Group	Mean	SD	*t*	*P*
8. The Team Leader followed the	Low-Fidelity	4.07	2.02	-2.65	.009*
appropriate ACLS algorithm	High-Fidelity	5.13	1.99		
9. The Team Leader recognized	Low-Fidelity	4.96	1.57	-2.00	.048*
the ECG rhythm changes	High-Fidelity	5.60	1.67		
10. The Team Leader provided	Low-Fidelity	3.69	1.66	-3.22	.002*
appropriate post arrest care	High-Fidelity	4.79	1.81		
11. The Team Leader	Low-Fidelity	4.17	1.71	-2.64	.010*
demonstrated confidence	High-Fidelity	5.06	1.71		
12. The Team Leader appeared	Low-Fidelity	3.98	1.76	-2.703	.008*
knowledgeable	High-Fidelity	4.94	1.80		
13. What is your overall feeling	Low-Fidelity	4.28	1.61	-2.21	.030*
about this Team Leader	High-Fidelity	5.02	1.79		
14. What is your overall feeling	Low-Fidelity	4.54	1.54	-1.65	.102
about this Team	High-Fidelity	5.06	1.68		

* $p < .05$

Hypothesis 2

The second hypothesis stated:

> Students who use high-fidelity manikin-based patient simulators will have greater anticipated confidence in responding appropriately to real-world situations as demonstrated in self-administered post-intervention quantitative and qualitative survey assessment compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

This hypothesis was tested using the Participant Self-Assessment. Subjects completed this instrument twice. The first instance was at the beginning of the study course and was reported earlier. The second instance was at the completion of the course. The mean score for the low-fidelity manikin group for the post-course Participant Self-Assessment was 60.67 (SD = 6.32). The mean score for the high-fidelity manikin-based simulation group was 61.06 (SD = 5.74). There was no statistical difference between the groups regarding subjects' ACLS confidence at the conclusion of the course. $t(32) = -0.190$, $p = .850$ (two-tailed). Hypothesis 2 was not supported.

Research question 1

The first research question stated:

> Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of affect towards the course content as measured by the Affective Learning Scale instrument in an American Heart Association Advanced Cardiovascular Life Support program?

This research question was tested with the Affective Learning Scale. This instrument was administered at the completion of the course. The low-fidelity manikin group had a mean score of 138.53 (*SD* = 2.40). The high-fidelity manikin-based simulation group had a mean score of 136.81 (*SD* = 5.02). There was no statistical difference between these two groups, $t(31) = 1.265$, $p = .215$ (two-tailed). Research Question 1 did not indicate significance for either high-fidelity manikin-based simulation or for low-fidelity simulation.

Research question 2

The second research question stated:

> Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of motivation towards the course content as measured by the Student Motivation Scale in an American Heart Association Advanced Cardiovascular Life Support program?

This research question was tested with the Student Motivation Scale. This instrument was administered at the completion of the course. The low-fidelity manikin group had a mean score of 80.00 (*SD* = 3.65). The high-fidelity manikin-based simulation group had a mean score of 79.81 (*SD* = 4.86). There was no statistical difference between these two groups, $t(32) = .128$, $p = .899$ (two-tailed). Research Question 2 did not indicate significance for either high-fidelity manikin-based simulation or for low-fidelity simulation.

Ancillary Findings

The course pretest indicated the low-fidelity manikin group had a higher degree of ACLS knowledge compared to the high-fidelity manikin-based simulation group (p = .005). The mean score for the low-fidelity manikin group was 72.0 (SD = 9.60). The mean score for the high-fidelity simulation group was 61.5 (SD = 10.82). This advantage for the low-fidelity manikin group was erased on the posttest. The mean score for the low-fidelity manikin group on the posttest was 87.78 (SD = 9.05). The mean score for the high-fidelity simulation group was 90.00 (SD = 7.59). There was no statistical difference in subjects' ACLS knowledge at the conclusion of the course. $t(32) = -.770$, $p = .447$ (two-tailed).

The differences between the two groups' pretest and posttest were tested. The mean difference for the low-fidelity manikin group was 15.79 (SD = 11.19). The mean difference for the high-fidelity manikin-based simulation group was 28.50 (SD = 10.92). These results showed the high-fidelity manikin-based simulation group improved their cognitive knowledge at a significant level when compared to the low-fidelity manikin group, $t(32) = - 3.348$, $p = .002$ (two-tailed).

The high-fidelity manikin-based simulation group did have a higher percentage of associate degree program nurses in it than did the low-fidelity manikin group. A t test was performed to determine if there was a difference in posttest improvement comparing associate degree nursing students to bachelor degree nursing students. The mean difference for the associate degree nursing students was 23.37 (SD = 9.73). The mean difference for the bachelor degree nursing students was 19.73 (SD = 15.75). There was no statistically significant finding in these results, $t(32) = .928$, $p = .414$ (two-tailed).

As an education intervention, the ACLS course resulted in significant improvement in subjects' cognitive knowledge. A paired sample *t* test comparing the ACLS pretest with the ACLS posttest in both groups combined showed the pretest had a mean of 67.06 (SD = 11.36) and the posttest had a mean of 88.52 (SD = 8.34). This result was significant in demonstrating the course could improve cognitive knowledge, $t(33) = -10.027$, $p = .000$. Looking at each group, the results were similar. For the low-fidelity simulation group, the pretest had a mean of 72.00 (SD = 9.60) and the posttest had a mean of 87.78 (SD = 9.05). This result was significant in demonstrating the course could improve cognitive knowledge, $t(17) = -5.984$, $p = .000$. For the high-fidelity manikin-based simulation group, the pretest had a mean of 61.50 (SD = 10.82) and the posttest had a mean of 90.00 (SD = 7.59). This result was significant in demonstrating the course could improve cognitive knowledge, $t(15) = -10.442$, $p = .000$.

Summary of the Findings

Thirty-seven subjects initially participated in the study with 20 in the low-fidelity manikin group and 17 in the high-fidelity manikin-based simulation group. Attrition during the course created a final participant number of 34 with 18 in the low-fidelity manikin group and 16 in the simulation group.

The mean age of the subjects was 32.5 (31.8 in the low-fidelity manikin group and 33.4 in the high-fidelity manikin-based simulation group). There were 5 males and 32 females in the study (85% females in the low-fidelity manikin group and 88.2% females in the high-fidelity manikin-based simulation group). 15 subjects were from bachelor degree nursing programs and 22 subjects were from associate degree nursing programs (55% bachelor degree nursing students in the low-fidelity manikin group and

35.3% bachelor degree nursing students in the high-fidelity manikin-based simulation group). 51.4 percent of the participants had prior health care experience (50% in the low-fidelity manikin group and 52.9% in the high-fidelity manikin-based simulation group). Only one subject had prior ACLS experience (none in the low-fidelity manikin group and one in the high-fidelity manikin-based simulation group).

Hypothesis 1, which asserted that competence as demonstrated in post-intervention skills assessments would be higher for the high-fidelity manikin-based simulation group, was not supported (p =.122). Of the 14 items on the assessment instrument, seven indicated significance at the alpha level 0.05 favoring the high-fidelity manikin-based simulation group over the low-fidelity manikin-based simulation group. All other items showed a higher mean score favoring the simulation group, but these scores did not reach levels of significance. Hypothesis 2, which asserted greater anticipated confidence in responding appropriately to real-world situations would be higher for the high-fidelity manikin-based simulation group, was not supported (p =.850).

Research question 1, which examined if one group would demonstrate a greater degree of affect towards the course content, did not demonstrate significance favoring either group (p =.215). Research question 2, which examined if one group would demonstrate a greater degree of motivation towards the course content, did not demonstrate significance favoring either group (p =.899).

The high-fidelity manikin-based simulation group had a significantly higher rate of improvement on the posttest when compared to the pretest (p = .002). This improvement negated the significant precourse knowledge advantage the low-fidelity manikin group had on the pretest (*p* = .005). On the posttest, neither group performed significantly better than the other (*p* = .447).

For both groups, there was significant improvement in knowledge when comparing the pretest and posttest scores (*p* = .000 for the combined groups; *p* = .000 for the high-fidelity manikin-based simulation group; and *p* = .000 for the lower fidelity simulation group). The high-fidelity manikin-based simulation group significantly improved their cognitive knowledge when the difference between pretest and posttest scores were compared to the low-fidelity manikin group, *t*(32) = - 3.348, *p* = .002 (two-tailed).

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

The purpose of Chapter Five is to present a summary of the work and the researcher's conclusion. This chapter will include the purpose of the study, the population and sample, methods, findings, conclusions, implications, and recommendations for future research in the subject are provided.

Purpose

The purpose of this study was to determine if the use of high-fidelity manikin-based patient simulators improves the educational outcomes of students as compared to the educational outcomes in students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support course. Four specific areas were examined which included two hypotheses and two research questions:

H^1 Students who use high-fidelity manikin-based patient simulators will have better competence as demonstrated in post-intervention skills assessments graded by an expert rater compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

H^2 Students who use high-fidelity manikin-based patient simulators will have greater anticipated confidence in responding appropriately to real-world situations as demonstrated in self-administered post-intervention quantitative and qualitative survey assessment compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program.

Q^1 Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of affect towards the course content as measured by the Affective Learning Scale instrument in an American Heart Association Advanced Cardiovascular Life Support program?

Q^2 Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of motivation towards the course content as measured by the Student Motivation Scale in an American Heart Association Advanced Cardiovascular Life Support program?

Population and sample

The intended population of this study was senior nursing students from four area nursing programs. However, low enrollment from one school required termination of their participation. Senior nursing students were chosen because they possessed the basic medical knowledge needed for the course but were relatively naïve to Advanced Cardiovascular Life Support skills. The sample was a convenience sample in which subjects self selected to one of two dates which classes were being offered as part of the study. Due to subject scheduling issues, it was not possible to make random assignment of subjects to specific study course dates. Although subjects were able to select their own course dates, subjects were unaware of which intervention was being conducted in their selected course. A quota system was employed to balance enrollment from the participating schools in each study group.

Final attendance of the program was 37 with 20 in the low-fidelity manikin study group and 17 in the simulation study group. Distribution of the subjects according to nursing school for the low-fidelity manikin group was six from school A, six from school B, and seven from school C plus one from the fourth school from which one student was inadvertently enrolled. Distribution of the subjects according to nursing school for the simulation group was nine from school A, two from school B, and six from school C.

The low-fidelity manikin group had two subjects who did not complete the program. One subject became ill during the course and withdrew. One subject withdrew due to a family issue. The final *n* for the low-fidelity manikin group was 18. The simulation group had one student withdraw due to illness on the morning of the second day. The final *n* for the simulation group was 16. The combined *n* for course completers for the study was 34.

Both groups shared similar demographic data regarding age, gender, prior healthcare experience, and prior ACLS experience. The simulation group had a slight bias to enrolling more associate degree nurses than the low-fidelity manikin group. A pretest administered to both study groups showed the low-fidelity manikin group had a higher degree of incoming ACLS knowledge than the simulation group ($p = .005$). Both groups reported a similar measure of their self-reported confidence with ACLS skills coming into the course ($p = .309$).

The total number of subjects who completed the program was 34. While small, this number is not atypical for studies of this type (Bradley, 2006). For example, there have been several published studies on ACLS course efficacy or simulation effectiveness with subject numbers that were similar to this study's including Abrahamson, Denson, &

Wolf (1969) – 10 subjects; Boonmak, Boonmak, Srichaipanha, & Poomsawat (2004) – 39 subjects; Chopra, Gesink et al. (1994) – 28 subjects; Dalley, Robinson, Weller, & Caldwell (2004) – 18 subjects; Hall et al. (2005) – 36 subjects; Marchette et al. (1985) – 37 subjects; Pittini et al.,(2002) – 30 subjects; Quan, Shugerman, Kunkel, & Brownlee (2001) – 39 subjects; Steadman et al. (2006) – 31 subjects; and Wayne et al. (2005) –38 subjects.

Methods

The intervention for this study was the American Heart Association Advanced Cardiovascular Life Support course. The independent variable was the type of educational technology utilized – with one group receiving ACLS training using high-fidelity manikin-based patient simulators and the other group using low-fidelity manikins.

All components of the two interventions courses were identical with one exception. In one course, high-fidelity manikin-based patient simulators were used with all features of the simulators activated and accessible to the subjects. Subjects acquired all clinical information needed for completion of scenarios from the simulator. In the other course, the high-fidelity manikin-based patient simulators were not activated. By doing this, the device did not function in a high-fidelity manner. Instead, it was used as a static, low-fidelity manikin more traditionally used in ACLS courses. Subjects were reliant on obtaining a significant portion of the clinical information needed for the scenario by asking questions of the ACLS Instructor.

Six instrument measures were used for data collection:

- Demographic Survey Form

- ACLS Written
- ACLS Mega Code Performance Score Sheet (Modified)
- Participant Self-Assessment
- Affective Learning Scale
- Student Motivation Scale

This study was a quasi-experimental design. Two groups were used – the high-fidelity simulation and the low-fidelity simulation group. The subjects from the convenience sample were self-assigned into two groups. All subjects were blinded to the group treatments during selection. In order to balance subject participation to equal representation from all participating schools of nursing, a quota assignment was utilized.

Subjects attended both days of a two-day ACLS Provider Course, defined as the *intervention*. After final evaluation scenarios, all subjects had an additional skills performance video recorded. These scenarios were performed with the simulator activated for both groups. This was done in order to allow a panel of expert raters to judge the ability of subjects to transfer the skills to life-like situations. Because the low-fidelity manikin group did not have experience with the simulator in the activated mode, an orientation to the simulator was conducted prior to final evaluations and included non-cardiac arrest scenarios. The panel of three expert raters scored each subject using the modified ACLS Mega Code Performance Score Sheet. Results from the three expert raters were combined to create mean scores for each subject on each item response for the ACLS Mega Code Performance Score Sheet. These mean scores were then compiled to produce an overall mean for each group.

After the completion of the ACLS course but prior to the simulated skills evaluation, subjects completed the final three self-administered instruments. This included the Participant Self-Assessment, the Student Motivation Scale, and Affective Learning Scale.

Findings

Thirty-seven subjects initially participated in the study with 20 in the low-fidelity manikin group and 17 in the simulation group. Attrition during the course created a final participant number of 34 with 18 in the low-fidelity manikin group and 16 in the simulation group.

Both groups presented with similar demographic data. The mean age of the subjects was 32.5 (31.8 in the low-fidelity manikin group and 33.4 in the simulation group). There were 5 males and 32 females in the study (85% females in the low-fidelity manikin group and 88.2% females in the simulation group). Fifteen subjects were from bachelor degree nursing programs and 22 subjects were from associate degree nursing programs (55% bachelor degree nursing students in the low-fidelity manikin group and 35.3% bachelor degree nursing students in the simulation group). Regarding experience, 51.4 percent of the participants had prior health care experience (50% in the low-fidelity manikin group and 52.9% in the simulation group). Only one subject had prior ACLS experience (none in the low-fidelity manikin group and one in the simulation group).

Summary of the major findings

Hypothesis 1 stated that students who use high-fidelity manikin-based patient simulators will have better competence as demonstrated in post-intervention skills assessments graded by a panel of expert raters compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program. Hypothesis 1 was not supported (*p* =.122). Of the 14 items on the assessment instrument, seven indicated significance at the alpha level 0.05 or greater favoring the high-fidelity manikin-based simulation group over the low-fidelity manikin-based simulation group. All other items showed a higher mean score favoring the simulation group, but these scores did not reach levels of significance.

Hypothesis 2 stated students who use high-fidelity manikin-based patient simulators will have greater anticipated confidence in responding appropriately to real-world situations as demonstrated in self-administered post-intervention quantitative and qualitative survey assessment compared to students who used low-fidelity manikins in an American Heart Association Advanced Cardiovascular Life Support program. Hypothesis 2 was not supported (*p* =.850). None of the 10 items on the assessment instrument demonstrated significance at the item level.

Research Question 1 asked, “Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of affect towards the course content as measured by the Affective Learning Scale instrument in an American Heart Association Advanced Cardiovascular Life Support program?” The results of this study did not demonstrate significance favoring either group (*p* =.215).

Research Question 2 asked, “Do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of motivation towards the course content as measured by the Student Motivation Scale in an American Heart Association Advanced Cardiovascular Life

Support program?" The results of this study did not demonstrate significance favoring either group (p =.899).

Ancillary Findings

At the start of the program, the low-fidelity manikin group had a higher degree of ACLS knowledge than the simulation group (p = .005). However, posttest scores were not significantly different (p = .447). The degree of improvement from the pretest to the posttest was significantly greater for the simulation group (p = .002). For both groups, there was significant improvement in knowledge when comparing the pretest and posttest scores (p = .000 for the combined groups; p = .000 for the high-fidelity manikin-based simulation group; and p = .000 for the lower fidelity simulation group).

Conclusions

While none of the hypotheses or research questions found significance favoring either the high-fidelity manikin-based simulation group or the lower fidelity simulation group, there were several relevant conclusions that can be drawn from the data. Regarding Hypothesis 1, which stated that students who use high-fidelity manikin-based patient simulators will have better competence as demonstrated in post-intervention skills assessments graded by an expert rater compared to students who used low-fidelity manikins, the overall scale did not indicate a significant superiority for high-fidelity manikin-based patient simulation over the use of lower fidelity manikins; although, it did show higher scores for the high-fidelity manikin-based simulation group on both the overall scale level and on all items. However, on reviewing the findings at the item level, several significant findings favoring the high-fidelity simulation group over the low-fidelity manikin group emerged. Of the 14 items in the scale, 7 indicated significant differences between the groups that favored the high-fidelity manikin-based simulation group. The seven items were:

- Item 2 – The Team Leader assigned team member roles
- Item 8 – The Team Leader followed the appropriate ACLS algorithm
- Item 9 – The Team Leader recognized the ECG rhythm changes
- Item 10 – The Team Leader provided appropriate post arrest care
- Item 11 – The Team Leader demonstrated confidence
- Item 12 – The Team Leader appeared knowledgeable
- Item 13 – What is your (expert rater) overall feeling about this Team Leader?

On reviewing the items that were not found to be significant, there were some commonalities. Activities that required psychomotor skills to be managed by the team leader (CPR, attaching the monitor, basic airway management, and utilizing defibrillation) did not generate significant differences between the groups. Another common point in the non-significant items was the interventions and actions that took place in the opening minutes of the scenarios did not indicate a significant difference favoring either group. This included the ability of the team leader to recognize the initial rhythm and order the correct treatment for the initial rhythm. Actions that took place later in the scenario such as appropriately managing subsequent ECG rhythm changes and post-resuscitation care significantly favored the high-fidelity manikin-based simulation group.

These conclusions indicate that the high-fidelity manikin-based simulation technology was not as useful in teaching the management of psychomotor skills in a cardiac arrest. Additionally, both high-fidelity manikin-based simulation and the use of lower levels of simulation fidelity did equally as well in teaching team leaders the knowledge and skills to manage the opening minutes of a cardiac arrest. However, as the event progressed and the complexity of the scenario increased, high-fidelity manikin-based simulation proved to be better than simulation of lower fidelity as demonstrated by the knowledge and actions of the team leader. These findings are supported by other authors who have indicated that full-environment high-fidelity simulation may not be needed for all cognitive learning objectives (W. B. Murray & Schneider, 1997; Salas & Burke, 2002)

High-fidelity manikin-based simulation is not routinely used for teaching basic skills such as basic airway management, cardiopulmonary resuscitation (chest compressions), and defibrillation. These data indicate that the use of lower fidelity manikins may be as efficacious as higher fidelity manikins in teaching basic level resuscitation skills. However, as the situation evolved and became more complex the high-fidelity manikin-based simulation group was viewed as being significantly more knowledgeable on managing the scenario. The scenarios used in the ACLS courses also required the integration of knowledge, basic psychomotor skills, and critical thinking rather than examining each as an individual function. McCausland, Curran, and Cataldi (2004) noted that simulation was an effective way to integrate these three skill sets.

One surprising result on reviewing the items on the ACLS Mega Code Performance Score Sheet was the item that referenced the expert raters' overall feelings about the team. Several pervious published studies reported high-fidelity manikin-based simulation as a tool for teaching teamwork (Beaubien & Baker, 2004; DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005; Fiedor & DeVita, 2004; Grenvik, Schaefer, DeVita, & Rogers, 2004; Holcomb et al., 2002; Lighthall, 2004; H. T. Ostergaard, Ostergaard, & Lippert, 2004; Palmisano, Akingbola, Moler, & Custer, 1994; Raemer, 2004; Shapiro et al., 2004; J. Weller, 2004; Wright, Taekman, & Endsley, 2004). The high-fidelity manikin-based simulation group in this study did not experience a significant advantage over the low fidelity group. Both groups received high scores on their teamwork ability (4.54 for the low-fidelity group and 5.06 for the high-fidelity group). As an intervention, ACLS – even without high-fidelity manikin-based simulation – has been shown to improve outcomes and previous studies have indicated that team performance is enhanced (Birnbaum et al., 1994; Camp, Parish, & Andrews, 1997). The ACLS course emphasizes team skills and communications. There is a video that demonstrates effective team performance and the ACLS practice stations emphasize the use of these skills. Thus, it is possible that ACLS alone may have been enough to improve team skills. The addition of high-fidelity manikin-based simulation did not enhance the ability of the high-fidelity group to increase their team skills over the low-fidelity group.

Additionally, cardiac arrest teams are very different than many other teams in medicine. Unlike operating room teams or trauma resuscitation teams who frequently work together, cardiac arrest teams often form for the first time when they respond to a real event. While cardiac arrest teams have assigned roles, the people who fill these roles are often interchangeable and the individuals assigned to fill these roles frequently rotate according to schedules and other assignments. This makes the concept of “team” very different from most healthcare teams that have been studied in high-fidelity manikin-based simulation. These differences may make team performance in cardiac arrest management different from other medical teams.

Regarding Hypothesis 2, which stated students who use high-fidelity manikin-based patient simulators will have greater anticipated confidence in responding appropriately to real-world situations compared to students who use manikins of lower fidelity, both groups exhibited a very high level of self-reported confidence in their perceived ability to manage a real-life cardiac emergency. Previously published reports on the effectiveness of the ACLS course as an educational program have shown that ACLS is an effective intervention (Birnbaum et al., 1994; Boonmak, Boonmak, Srichaipanha, & Poomsawat, 2004; Camp, Parish, & Andrews, 1997; Dane, Russell-Lindgren, Parish, Durham, & Brown, 2000; Lowenstein, Sabyan, Lassen, & Kern, 1986; Makker, Gray-Siracusa, & Evers, 1995; Marchette et al., 1985; A. B. Sanders et al., 1994). The data from this study indicates that ACLS – regardless of the level of simulation being used – improves participants' confidence in performing emergency cardiovascular care in real-life situations.

In their summary report on simulation in nursing education, Jeffries and Rizzolo (2006) noted subjects who participated in programs using either the patient simulator or a static manikin both reported significantly more confidence than subjects who received the same education in a paper and pencil simulation. While comparisons between the patient simulator and static manikin groups were not reported, it was implied there was no statistical difference their levels of confidence. Jeffries and Rizzolo also reported that subjects from all three groups did not demonstrate significant differences in self-reported performance. The authors indicated this non-significance was a product of all groups being able to achieve stated program objectives. As they stated, “It appears that students self-evaluate on the context of the learning situation. (p. 8).” This same rationale may also provide some explanation for the non-significant results for both Research Questions.

Research Question 1, which asked “do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of affect towards the course content,” did not indicate any significant difference between the groups. Scores from Affective Learning Scale were very high for both groups indicating that the ACLS course had a positive impact on subject affect towards course content regardless of the level of simulation being used. The subjects in both ACLS courses in this study came to the program well prepared and ready to learn. Birnbaum et al.(1994) stated preparation was a key determinant of student attrition in the courses they studied and those subjects who were prepared did well even if they were not regular members of cardiac arrest teams.

Research Question 2, which asked “do students using high-fidelity manikin-based patient simulators compared to students who used low-fidelity manikins demonstrate a greater degree of motivation towards the course content,” also did not indicate any significant difference between the groups. Marchette et al. (1985) noted that ACLS students demonstrated high degrees of motivation in their study. As graduating nursing students preparing to enter the workplace, subjects in this study were highly motivated to participate in the ACLS course. The type of simulation utilized did not affect this motivation.

When reviewing the non-significant findings in this study it is relevant to look at the contribution of the instructors. The instructors utilized in both classes represented expert instructors with many years of experience. The use of high-fidelity manikin-based simulation for ACLS education had been employed in this training center for over one year. Prior to that, these instructors were highly adept at meeting the course objectives utilizing manikins of lower fidelity.

Despite starting at a significant disadvantage on baseline ACLS knowledge as determined by the pretest, the high-fidelity manikin-based simulation group improved at a significantly better rate than the low-fidelity manikin group. This improvement resulted in posttest scores that showed both groups near even in their ACLS knowledge. This improvement in knowledge combined with the expert raters' determination that the high-fidelity manikin-based simulation group demonstrated significantly more overall knowledge and confidence while running a simulated cardiac arrest indicate support for high-fidelity manikin-based simulation as an effective means for teaching cognitive knowledge in emergency cardiovascular care.

Advanced Cardiovascular Life Support is an effective program for increasing student knowledge in emergency cardiovascular care as demonstrated by a pretest/posttest comparison. While the high-fidelity manikin-based simulation group had a higher degree of knowledge gain, both groups significantly improved their knowledge by participating in the ACLS program. While other studies have been published on the efficacy of ACLS as an education intervention, this is the first study completed on the most recent version of the course.

Both the low-fidelity and high-fidelity manikin-based ACLS courses utilized immersive environments. The manikins were life-like in appearance, the learning space looked like an actual clinical room, and the equipment that was used was real therapeutic equipment. Scenarios required the subjects to act as healthcare providers and make appropriate clinical decisions and interventions. On examination of student written comments at the conclusion of the program, subjects from both groups indicated the experience was very realistic. The elements of experiential learning were present for both groups. The experiential learning cycles forwarded by Lewin and Kolb were actively utilized in both courses. This included a reflective process and the opportunity to repeat scenarios for subjects to test new actions. The technology available for the high-fidelity manikin-based simulation offered richer debriefing data than the instructor-led debriefing used with the low-fidelity group. The richness and detail of this data may offer one explanation as to why the high-fidelity manikin-based simulation group was able to score significantly higher in items that occurred later in the scenarios. Being reliant on only instructor notes and memory, the low-fidelity group may have had missed opportunities for full reflection on the scenario.

Another learning theory approach that had relevance to this group was adult learning theory. In reviewing Knowles' (Knowles, Holton, & Swanson, 1998) six principles, subjects in both of the study courses demonstrated these assumptions. The scenarios were very lifelike, even in the low-fidelity group. Subjects quickly discovered their knowledge gaps and had an intrinsic desire to correct their actions and improve their knowledge to be able to adequately care for the next simulated patient. The subjects from both groups demonstrated a high-degree of motivation and self-responsibility. Subjects completed precourse self-assessments and studied for the program. The subjects brought a wide range of life-experiences to the course, although they all had the common frame of reference as senior nursing students. They demonstrated a readiness to learn and through the experiential learning cycle were able to make improvements in their actions that allowed them to move from one level of knowledge to the next. As students preparing to enter the nursing workforce, the program was highly life-centered and demonstrated a high degree of relevance to their future. There was no requirement from any of the subjects' nursing programs to participate in these courses. Participation indicated a high level of self-motivation.

A third learning theory that was demonstrated in these courses were the brain-based learning concepts advanced by Caine and Caine (1991). Their three essential elements were present throughout the courses. The courses were presented in a non-threatening manner and information was presented in an incremental fashion as to limit the possibility of overwhelming the subjects. Additionally, there were teaching stations early in the course that allowed for the development of basic skills. These learning stations provided the opportunity for the subjects to build confidence and remain engaged while being continually challenged with new concepts as the courses progressed. Even in the low-fidelity group, there was an orchestrated immersion in complex experiences as subjects worked their way through a series of cardiovascular crisis scenarios. Through the reflective process, they were able to link successes and failures of previous scenarios to the present scenario allowing them to build on their experiences, much in the manner advocated in constructivist thought. Lastly, both groups had to actively process the experience, utilizing feedback (either from the instructor or from the high-fidelity simulator) in order to determine a course of action.

The high-fidelity manikin-based simulation group may have been more involved than the low-fidelity manikin group in all three of these elements. The realism of the high-fidelity manikin including its ability to talk to the subjects expressing pain or apprehension may have created a heightened state of alertness and urgency for action in the high-fidelity group. The richness of the high-fidelity simulators' debriefing data may have given that group a deeper learning experience upon which to draw on in later scenarios. The quality and realism of the feedback gave the high-fidelity group a more immersive experience and better data on which to take action.

Implications

As mentioned in the opening chapter, high-fidelity manikin-based patient simulation is an expensive resource. Finding the most appropriate areas to utilize this technology is important for education directors and instructors. There may be certain skills or knowledge that manikins of lower fidelity may be a more cost effective option without losing efficacy. Conversely, there are skills and knowledge that can be enhanced by using high-fidelity manikin-based simulation.

The results of this study would indicate that:

- Psychomotor skills such as CPR, basic airway management, defibrillation, and use of monitoring equipment are learned equally well with either high-fidelity manikin-based simulation or by using manikins of lower fidelity.

- Observed knowledge of cardiac arrest management is improved with the use of high-fidelity manikin-based simulation.
- Observed confidence of healthcare providers as demonstrated in simulated cardiac arrest events is improved with high-fidelity manikin-based simulation.
- As scenarios progressed and became more complex, the high-fidelity manikin-based simulation group differentiated itself by showing significant observed performance capabilities over the low-fidelity manikin group.
- Advanced Cardiovascular Life Support improves student knowledge, self-reported confidence, increases affect towards emergency cardiovascular care course content, and is a motivator for students to learn more about emergency cardiovascular care. As an education intervention, ACLS is an effective program.

High-fidelity manikin-based simulation had a greater impact on observed student knowledge after the first minutes of a simulated cardiac arrest event. High-fidelity manikin-based simulation also improved posttest scores over pretest scores at a higher rate than did lower fidelity simulation. High-fidelity manikin-based simulation has a role in Advanced Cardiovascular Life Support. However, learning stations that emphasize basic skills such as CPR and basic airway management may by equally well addressed with manikins of lower fidelity.

Recommendations for Future Research

The findings of this study suggest several opportunities for future research.

1. This study used senior nursing students as subjects. There are many other types of healthcare providers as well as other healthcare providers with more experience. Studies focusing on other types of healthcare providers, such as paramedics, physicians, or respiratory therapists offer opportunities for replication of this study. In addition, healthcare providers with more experience – including nurses – present good potential for additional research.
2. The healthcare providers used in this study were a homogenous group. Conducting the same study in a more heterogeneous group that would more typify actual cardiac arrest team makeup would be beneficial, especially in relation to the teamwork concepts.
3. Advanced Cardiovascular Life Support is only one course type. There are several other standardized programs such as Pediatric Advanced Life Support. Investigation of the impact of simulation in these other course types represents another area for future research.
4. This study examined immediate posttesting after the intervention programs. It did not address knowledge and skill retention. Determining if there are lasting effects on knowledge and skills at later time periods after the intervention would be valuable.
5. This study manipulated only one variable (simulation technology). Other variables that are often associated with high-fidelity manikin-based simulation

such as the realism of the learning environment, the realistic look of the manikin, and the use of actual clinical equipment may be useful.

6. Results of this study showed there was a difference in the efficacy of using simulation in basic or advanced skills. Additional research focusing on this difference would be valuable.

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APPENDICES

APPENDIX A: ACLS COURSE AGENDA

ACLS Provider Course Agenda

Day 1

0800		Welcome/Introduction/Overview/Organization		
0810		Paperwork – Survey completion		
0900		BLS Primary Survey/ACLS Secondary Survey		
0930		Station Rotations (4 groups of 6 students)		
	0930	Airway 1	Group A	Group B
	1000	Break		
	1015	CPR/AED 1	Group B	Group A
	0930	Airway 2	Group C	Group D
	1000	Break		
	1015	CPR/AED 2	Group D	Group C
1045		Technology Review		
1100		The ACLS Mega Code		
1120		VF Stations		
		Team 1		
		Team 2		
		Team 3		
1220		Lunch		
1300		Station Rotations		
		ACS/Stroke	Brady/PEA/ Asystole	Tachycardias
	1300	Team 1	Team 2	Team 3
	1400	Team 3	Team 1	Team 2
	1500	Team 2	Team 3	Team 1
1600		Questions		
1630		End of Day 1		

Day 2

0800	Questions/Expectations for testing
0815	Putting it all together (Random case review)
	Team 1, Team 2, & Team 3 to assigned rooms
0945	Break
1000	Mega Code
	Team 1, Team 2, & Team 3 to assigned rooms
1130	Written Test
1200	Lunch
1230	Final Survey
1315	Simulation Orientation
1345	Final Scenario Station
	Team 1, Team 2, & Team 3 to assigned rooms
1530	Course adjournment

APPENDIX B: LAERDAL SIMMAN FEATURES

Laerdal SimMan Features

- Full-scale manikin-based patient simulator.
- Interactive manikin that provides immediate feedback to interventions.
- Simulated patient monitor with touch-screen technology including the possibility to configure layout and content to mach simulation environment. Patient monitor can provide snap shot of x-ray, 12-lead ECG and trends.
- Simulated monitor capable of showing five waveforms (ECG, SpO2, ABP, PAP, and etCO2) and numeric reading for heart rate, pulse, SpO2, peripheral temperature, blood temperature, ABP (with mean), PAP, cardiac output, NIBP (with mean), train of four, and monitoring of anesthesia gases
- Software capabilities to run pre-programmed scenarios.
- Trend curves on instructor's panel control show the physiological parameters will change over time, and multiple trends can be run simultaneously with their effects added together
- Simulator utilizes software generating automatic debriefing, based on the event log synchronized with video pictures, which provide immediate, detailed feedback on performance to learners
- Bronchial tree is anatomically accurate in size, color and texture and features the accurate anatomical landmarks necessary to facilitate realistic fiberoptic bronchoscopy
- Interchangeable pupils
- Spontaneous breathing with ability to control rate
- Ability to exhale carbon dioxide

- Palpable pulse points (bilateral carotid, left arm brachial, left arm radial, bilateral femoral)
- Heart sounds
- Lungs Sounds
- Bowel sounds
- Ability to speak with preprogrammed phrases or through instructor supplied voice with remote microphone and speaker embedded in manikin
- Airway capable of being manipulated (tongue edema, trismus, decreased cervical range of motion, pharyngeal edema, and laryngospasm)
- Ability to decrease lung compliance
- Ability to occlude one or both lungs for a simulated pneumothorax
- Database of drugs with associated physiological trends
- Procedures that can be performed on simulator include:
    - Chest tube insertion
    - Needle reduction of tension pneumothorax
    - Needle and surgical cricothyrotomy
    - Insertion of intravenous catheter with blood return
    - Ability to perform phlebotomy for drawing simulated blood
    - Insertion of Foley catheter with fluid return
    - Defibrillation
    - Cardioversion
    - Transcutaneous pacing
    - 4-lead ECG monitoring

- Ability to obtain blood pressure by auscultation or palpation
- Placement of nasogastric tube

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Adapted from Laerdal SimMan Internet Web Site, accessed Sept. 1, 2006,

http://www.laerdal.com/document.asp?subnodeid=7320252

APPENDIX C: DEMOGRAPHIC SURVEY FORM

Demographic Survey Form

Instructions: Please complete the following information

Age:	Gender: ❑ Female ❑ Male	
What level of nursing program are you currently enrolled?		❑ Diploma ❑ Associate Degree ❑ Bachelors Degree
Have you worked in healthcare before enrolling in your nursing program?		❑ Yes ❑ No
If you have worked in healthcare before, how many years?		
Have you ever taken an American Heart Association Advanced Cardiovascular Life Support course before?		❑ Yes ❑ No

Thank you for completing this information

APPENDIX D: ACLS MEGA CODE PERFORMANCE SCORE SHEET (MODIFIED)

ACLS Mega Code Performance Score Sheet (Modified)

Video Number: ________________________

Instructions: Immediately after viewing each recorded simulated cardiac arrest event, complete the following information in regards to the Team Leader for that cardiac arrest event.

Circle the number that corresponds to your rating of this individual’s performance.

Scale: 1 – Not competent, 7 – Highly competent

1. The Team Leader assured that high-quality CPR was in progress	1 2 3 4 5 6 7
2. The Team Leader assigned team member roles	1 2 3 4 5 6 7
3. The Team Leader assured that monitor leads were applied appropriately	1 2 3 4 5 6 7
4. The Team Leader assured the airway was being managed appropriately	1 2 3 4 5 6 7
5. The Team Leader recognized the initial ECG rhythm	1 2 3 4 5 6 7
6. The Team Leader properly utilized defibrillation	1 2 3 4 5 6 7
7. The Team Leader ordered the correct medication treatment for the initial rhythm	1 2 3 4 5 6 7
8. The Team Leader followed the appropriate ACLS algorithm	1 2 3 4 5 6 7
9. The Team Leader recognized the ECG rhythm changes	1 2 3 4 5 6 7
10. The Team Leader provided appropriate post arrest care	1 2 3 4 5 6 7
11. The Team Leader demonstrated confidence	1 2 3 4 5 6 7
12. The Team Leader appeared knowledgeable	1 2 3 4 5 6 7
13. What is your overall feeling about this Team Leader	1 2 3 4 5 6 7
14. What is your overall feeling about this Team	1 2 3 4 5 6 7

APPENDIX E: PARTICIPANT SELF-ASSESSMENT (PRECOURSE)

Participant Self-assessment

Instructions: Answer the following questions and circle the number that corresponds to your self-assessment of how you view yourself in regards to these skills.

Scale: 1 – Not competent, 7 – Highly competent

1. I know how to do high-quality CPR	1	2	3	4	5	6	7
2. I know what roles each person plays in a cardiac arrest	1	2	3	4	5	6	7
3. I know how to attach ECG leads in a cardiac arrest	1	2	3	4	5	6	7
4. I know how to manage an airway	1	2	3	4	5	6	7
5. I can recognize a lethal rhythm on the cardiac monitor	1	2	3	4	5	6	7
6. I know how to perform a defibrillation	1	2	3	4	5	6	7
7. I know what first line medications are used in cardiac arrest	1	2	3	4	5	6	7
8. I know how to follow the ACLS Pulseless Arrest Algorithm	1	2	3	4	5	6	7
9. I know what to do when the cardiac arrest patient gets a pulse back	1	2	3	4	5	6	7
10. I am confident in my ability to manage a cardiac arrest	1	2	3	4	5	6	7

APPENDIX F: PARTICIPANT SELF-ASSESSMENT (POSTCOURSE)

Participant Self-assessment

Instructions: Answer the following questions and circle the number that corresponds to your self-assessment of how you view yourself in regards to these skills.

Scale: 1 – Not competent, 7 – Highly competent

1. I know how to do high-quality CPR	1	2	3	4	5	6	7
2. I know what roles each person plays in a cardiac arrest	1	2	3	4	5	6	7
3. I know how to attach ECG leads in a cardiac arrest	1	2	3	4	5	6	7
4. I know how to manage an airway	1	2	3	4	5	6	7
5. I can recognize a lethal rhythm on the cardiac monitor	1	2	3	4	5	6	7
6. I know how to perform a defibrillation	1	2	3	4	5	6	7
7. I know what first line medications are used in cardiac arrest	1	2	3	4	5	6	7
8. I know how to follow the ACLS Pulseless Arrest Algorithm	1	2	3	4	5	6	7
9. I know what to do when the cardiac arrest patient gets a pulse back	1	2	3	4	5	6	7
10. I am confident in my ability to manage a cardiac arrest	1	2	3	4	5	6	7

What did you like about this course?

How realistic was the training to what you perceive a real cardiac arrest event to be like?

What were the major things you learned in this course?

Please use back of sheet if necessary for short answer questions

APPENDIX G: AFFECTIVE LEARNING SCALE

Instructions: Please respond to the following scales in terms of the class you have just taken. Circle one number on each set of bipolar scales to indicate your judgment or evaluation of the concept/idea about this class. Note that in some cases the most positive number is a "1" while in other cases it is a "7."

1. Behaviors recommended in this course:

Good	1	2	3	4	5	6	7	Bad
Worthless	1	2	3	4	5	6	7	Valuable
Fair	1	2	3	4	5	6	7	Unfair
Positive	1	2	3	4	5	6	7	Negative

2. Content/subject matter of the course:

Bad	1	2	3	4	5	6	7	Good
Valuable	1	2	3	4	5	6	7	Worthless
Unfair	1	2	3	4	5	6	7	Fair
Negative	1	2	3	4	5	6	7	Positive

3. Course instructors:

Good	1	2	3	4	5	6	7	Bad
Worthless	1	2	3	4	5	6	7	Valuable
Fair	1	2	3	4	5	6	7	Unfair
Positive	1	2	3	4	5	6	7	Negative

4. In "real life" situations, your likelihood of actually attempting to engage in behaviors recommended in this course:

Likely	1	2	3	4	5	6	7	Unlikely
Impossible	1	2	3	4	5	6	7	Possible
Probable	1	2	3	4	5	6	7	Improbable
Would Not	1	2	3	4	5	6	7	Would

5. Your likelihood of enrolling in another course of related content if your schedule so permits:

Unlikely	1	2	3	4	5	6	7	Likely
Possible	1	2	3	4	5	6	7	Impossible
Improbable	1	2	3	4	5	6	7	Probable
Would	1	2	3	4	5	6	7	Would Not

APPENDIX H: STUDENT MOTIVATION SCALE

Instructions: Please circle the number toward either word that best represents your feelings about Emergency Cardiovascular Care.

Motivated	1	2	3	4	5	6	7	Unmotivated
Interested	1	2	3	4	5	6	7	Uninterested
Involved	1	2	3	4	5	6	7	Uninvolved
Not stimulated	1	2	3	4	5	6	7	Stimulated
Don’t want to study	1	2	3	4	5	6	7	Want to study
Inspired	1	2	3	4	5	6	7	Uninspired
Unchallenged	1	2	3	4	5	6	7	Challenged
Uninvigorated	1	2	3	4	5	6	7	Invigorated
Unenthused	1	2	3	4	5	6	7	Enthused
Inspiring	1	2	3	4	5	6	7	Not inspiring
Not fascinated	1	2	3	4	5	6	7	Fascinated
Important	1	2	3	4	5	6	7	Unimportant

CURRICULUM VITAE
DAVID LEE RODGERS

EDUCATION

Marshall University
    Doctor of Education in Curriculum and Instruction, 2007
Marshall University
    Education Specialist (Ed.S.) in Curriculum and Instruction, 2003
Marshall University.
    Master of Arts in Communication Studies, 1999
West Virginia University.
    Bachelor of Science in Journalism, 1982

CERTIFICATIONS

National Registry of Emergency Technicians: National Registered Emergency Medical Technician – Paramedic

State of West Virginia Office of Emergency Medical Services: Emergency Medical Technician – Paramedic

American Heart Association: Advanced Cardiovascular Life Support Instructor, Advanced Cardiovascular Life Support Regional Faculty, Advanced Cardiovascular Life Support – Experienced Provider Instructor, Basic Life Support Instructor, Basic Life Support Regional Faculty, Pediatric Advanced Life Support Instructor

National Association of Emergency Medical Technicians: Pre-Hospital Trauma Life Support Instructor, Advanced Medical Life Support Provider

American Academy of Pediatrics: Pediatric Education for Prehospital Providers (PEPP) Course Coordinator

American Heart Association/American Academy of Pediatrics: Neonatal Resuscitation Provider

U.S. Department of Labor, Bureau of Apprenticeship and Training: Journeyman status as Emergency Medical Technician (Paramedic)

PROFESSIONAL EXPERIENCE

1985-1989	Lieutenant/Assistant Shift Supervisor, Paramedic, Kanawha County Emergency Ambulance Authority, Charleston, W.Va.
1986-1994	Flight Paramedic, Communications Specialist Supervisor, Manager of Pre-Hospital Services, Charleston Area Medical Center, Charleston, W. Va.
1994-Present	Education and Media Specialist, Life Support Training Center Coordinator, Business Development Manager, Associate Director of Education Division, CAMC Health Education and Research Institute, Charleston, W. Va.

HONORS AND RECOGNITIONS

2003-2005	International Liaison Committee on Resuscitation, Consensus 2005 Multi-disciplinary Task Force
2001-2004	American Heart Association National Program Administration Committee
2006	International Liaison Committee on Resuscitation, Delegate
2005-Present	American Heart Association National Emergency Cardiovascular Care Committee
2003-Present	American Heart Association National Emergency Cardiovascular Care Education Subcommittee (Chair, 2005-present)