Using Computer-Based Clinical Simulations to Improve Student Scores on the Paramedic National Credentialing Examination

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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Abstract

There is an impending shortage of paramedics within the United States, complicated by low success rates on the national credentialing examination and decreased access to clinical and field internship opportunities. The use of computer based-clinical simulations within paramedic education has the potential to provide improved access to student-patient interactions and a cost-effective, objectively measured, experiential-learning environment that may improve examination pass rates and ameliorate the paramedic shortage.

The primary objective of this study was to investigate differences in scores obtained on the national paramedic credentialing examination associated with use of computer-based clinical simulations, paramedic service type, and gender, after controlling for scores obtained on the national emergency medical technician (EMT) credentialing examination. A secondary purpose was to investigate faculty use of coaching, scaffolding, debriefing, and remediation pedagogies when implementing computer-based clinical simulations.

The quantitative research data, provided by the National Registry of Emergency Medical Technicians (NREMT), included 5966 student records completing the national paramedic credentialing examination during the inclusive dates of July 1, 2007 and June 30, 2008. The qualitative research data, provided by Elsevier Inc., producer of a clinical simulation product called Virtual Patient Encounters (VPE), included responses to focus
group interview questions from 9 paramedic faculty who used the VPE during the inclusive dates of the study.

Major findings of the quantitative analysis of this study included the absence of a significant effect of VPE usage on student examination performance, as well as an absence of significant higher order interaction effects. ANCOVA analysis revealed significant main effects for both service type and gender. Study participants indicating service type as fire-based or gender as male tended to achieve higher scores on the national paramedic credentialing examination, than did those study participants who indicated service type as non–fire-based or gender as female. However, the effect sizes were very small, suggesting little practical significance to these findings. The qualitative analysis of this study revealed paramedic faculty made little, if any, pedagogical changes when implementing the computer-based clinical simulation in the classroom. The lack of improvement in student examination scores is disappointing; however, it is clear that the use of VPE did not degrade student performance. This is an important finding when combined with the evidence that faculty failed to implement the computer-based clinical simulation product as recommended by the developer and failed to utilize the pedagogies necessary for success. This suggests that the use of computer-based clinical simulations may indeed improve student performance, if students are provided with the necessary tools and education to effectively use reflective thinking and faculty use the necessary pedagogies related to technology-based education.

The causal comparative nature of the current research suggests that future research in this arena should include a true experimental, balanced design that provides some level of understanding about the causal link between educational practice and
educational outcomes. Additional lines of inquiry, such as the theory underlying knowledge creation in simulation environments and the educator’s belief system with respect to educational simulations, are recommended.
Dedication

Dedicated to my wife and best friend,
Linda Kay Honeycutt Dickison
Acknowledgments

I wish to thank my advisor, Dr. Ayres D’Costa, for allowing this dissertation to grow from an idea to the scholarly research presented in the remaining pages of this manuscript; he allowed my dreams to become a reality.

Thank you, Dr. Ada Demb. The dedication you exhibit to student success and the support you provided me throughout the doctoral process will never be forgotten. You are truly the exemplar of what all individuals seeking to claim the title of educator should be. You were always available when I needed assistance and you challenged my thinking and arguments, leading me always to a deeper understanding of the topic.

Thank you, Dr. Dorinda Gallant. I am truly grateful for all the help you have provided me as a member of my committee. You were my co-advisor and even as you worked on your own important research projects, you never made me feel like I was a nuisance with my questions. More importantly, after Dr. D’Costa’s retirement, it was you who guided me through the preparation for the defense. It is my hope and prayer, that your research is successful and that the Ohio State University realizes the commitment you bring to the halls of academe.

Adam and Aaron Dickison, you are my sons and my friends. There is no Dad in this world that is more proud of his children than me. In the process of completing this Ph.D, you gave up many things, most of all family time. I know your lives were impacted, sometimes negatively, during the years of chasing my dream. I am truly sorry
for the bad times, but I am equally grateful that through it all, you never doubted me and always were there for me, even when I was not there for you. I love you guys.

Thank you, Mom and Dad. You created in me a foundation of work ethic, a determination to succeed, the ability to think, use common sense, and most of all a love of God that has directed my steps through this process.

I reserve my highest debt of gratitude to my lovely wife Linda. The sacrifices you made as I completed my research and developed the manuscripts can not be understood except by someone who has walked in your shoes. You were an editor, a cheerleader, a counselor, a taskmaster, a confidant, and most of all a true friend. To borrow a phrase from the movie Julie and Julia, you are the butter to my bread and the breath to my life.

“Let’s begin writing chapter three” -- I thank you with all my heart.
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Paramedicine

Occupational Technology
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1.1 Statement of the Problem

A paramedic shortage is emerging in the United States of America. Early warnings by the United States Department of Labor predicted that there would be a shortage of 21,000 paramedics by the year 2014. Then, in 2007, the Department of Labor nearly doubled their estimate, stating that 39,000 paramedics would be needed by the year 2016 to meet the needs of the American public (U.S. Department of Labor, 2007). In 2004, there were an estimated 117 million patients treated in emergency departments within the United States (American College of Emergency Physicians, 2005). According to the National Highway Traffic Safety Administration (2001), paramedics treat and transport approximately 25-30 million patients per year. This represents between 21.4% and 25.6% of all patients treated by emergency department physicians. While those transported by paramedics to emergency departments represent both genders of all ages, and from all socioeconomic and ethnic groups, it is estimated that more than 40% are over 75 years of age (Institute of Medicine, 2006). This important finding suggests that as the baby boomer generation grows older, the healthcare system will be increasingly taxed by their medical demands. As a result, an increasing number of qualified paramedics will be needed to adequately care for the number of patients requiring healthcare assistance.

Most current federal and local policy agencies investigating the issues
surrounding the anticipated paramedic shortage are focused on two areas: recruitment and retention. Their goals are to attract more individuals to select emergency medical services (EMS) as a career and to provide guidance for policy issues such as work hours, employee compensation, and safety. Although recruitment and retention are important issues, the key to solving the paramedic shortage is inexorably linked to educational outcomes and subsequent success on the national credentialing examination. Few references exist in the literature identifying specific variables linking educational outcomes to subsequent success on the national paramedic credentialing examination. One line of inquiry related to educational outcome and success on national paramedic credentialing examinations focuses on accreditation. Dickison, Hostler, Platt, and Wang (2006) and Fernandez, Studnek, and Margolis (2008) identified accreditation as a factor positively associated with success on the national paramedic credentialing examination. However, these researchers reported, of the students who successfully completed an accredited paramedic program, only 68% passed the national paramedic credentialing examination. The low national credentialing examination success rate results in a loss of 32% of those students initially recruited to meet the growing demand for paramedics who qualify to provide emergency care in the out-of-hospital environment; suggesting accreditation alone is insufficient to overcome the high degree of failure associated with the national paramedic credentialing examination (Dickison et al., 2006).

There are an increasing number of studies within general education literature focused on the use of simulations to improve the training of students and professionals. However, these studies have not focused on the impact on educational outcome when simulations are used in paramedic learning environments. A promising line of inquiry is
the use of simulation technology to improve educational outcomes in paramedic students. Simulations can provide a variety of experiential learning opportunities by placing students in virtual clinical settings and presenting them with both breadth and depth of virtual patient situations. In addition, these simulations promote active learning without threat to patients, while providing important mentoring opportunities during debriefings sessions that follow the student simulation experiences (Medley & Horne, 2005).

It is reasonable to generalize the advantages of simulation to the education of paramedics. Typical paramedic faculty pedagogy focuses on pattern recognition strategies that allow paramedic students to identify various patient assessment data that fit together, to explain injury or illness patterns and help direct decision making related to appropriate emergency medical care. Consistent and accurate pattern recognition permits paramedic students to identify how, when, and why patient assessment data deviate from expected injury and illness patterns (Higuchi & Donald, 2002). If clinical simulation tools can help paramedic students develop consistent and accurate pattern-recognition strategies, they can be used as a tool to help improve educational outcomes and subsequent success on the national paramedic credentialing examination. Improved pattern recognition should provide a better educational foundation for improving clinical judgment, decision-making, and educational outcomes, which will help ameliorate the impending paramedic shortage and ultimately improve patient outcomes in the actual field setting.
1.1.1 Introduction to the Problem

There is a projected shortage of paramedics qualified to provide out-of-hospital emergency medical care to the citizens of the United States. A contributing variable to this shortage of paramedics is the low success rate students experience on the national paramedic credentialing examination. The national paramedic credentialing examination is designed to evaluate the emergency medical care provider’s ability to function independently, while providing safe and effective care in the out-of-hospital setting (NREMT, 2004). The expectation of developers of the national paramedic credentialing examination is that the paramedic student’s ability to use knowledge and pattern-recognition strategies constructed in the classroom to solve various hypothetical clinical situations included in the national paramedic credentialing examination is a proxy measure of the student’s ability to limit morbidity and mortality in the patient population.

Typically, paramedic education program faculty utilizes a traditional classroom approach to disseminate information. Unfortunately this method fails to provide students with opportunities to actively apply knowledge and pattern-recognition strategies gained in the classroom in actual patient care experiences. The Emergency Medical Services (EMS) Education Agenda for the Future (1996) calls for paramedic program faculty to utilize educational theory and resources related to an experiential learning environment in order to help students become clinicians capable of making sound clinical judgments rather than technicians who rely solely on an algorithm to determine appropriate patient care. Current education standards require preceptor-observed clinical rotations and field internships for all paramedic students. The amount of time spent in these valuable student-patient interactions varies across the nation and is controlled by the patient
population, competitive placement, and state regulatory requirements.

The impact of utilizing innovative computer technology and clinical simulations by paramedic education program faculty to enhance a student’s ability to make appropriate decisions related to patient care and improve performance on the national paramedic credentialing examination has not been rigorously studied. Such simulations have the potential to help paramedic students improve the quality of care given to patients while overcoming the challenging task teaching decision making and clinical judgment in the paramedic classroom. The use of computer-based clinical simulations has the potential to provide paramedic education programs with equal or better access to student-patient interactions than traditional field internships and clinical rotations, and has the potential to improve performance on the national paramedic credentialing examination.

1.1.2 Setting

Training and education of paramedics has evolved from the late 1960s in response to a white paper presented to President Lyndon Johnson by the Institute of Medicine indicating a need for clearly defined standards of training for emergency medical response providers. The white paper resulted in the establishment of the National Highway Traffic Safety Administration and, in 1968, the release of the first national standard curriculum for emergency medical technicians (EMT). Since that time, the standards of education have been revised in response to identified deficiencies, a reactive rather than proactive model. Currently, paramedic training and education is offered in a variety of environments, including private EMS agencies, community colleges, universities, hospitals, medical centers, fire departments, and private educational centers.
(Delbridge, 1998). Although recent studies have suggested that paramedic program accreditation has a positive affect on student outcomes relative to credentialing success (Dickison et al., 2006; Fernandez, Studneck, and Margolis, 2008), less than 25% of paramedic programs within the United States have obtained an accredited status.

According to Ruple et al. (2005), while there are various environments where education of EMS providers is conducted, the process of providing education is fairly consistent and is typified by educators who follow a scripted lesson plan that is included in nationally standardized curricula. This corresponds to a traditional education approach, or transmission model, which emphasizes teacher-directed learning, uses noninteractive modes of knowledge dissemination, and preexisting ideas are merely transmitted to the learner. Few educators within these paramedic classroom settings utilize current research in medicine, education, or allied health to enhance classroom discourse or the interaction of theory and practice in the clinical setting, and only 22% of these educators believed that clinical experience as a paramedic was a useful characteristic of an educator. This finding is consistent with the report presented within the EMS Education Agenda for the Future (1996), which states:

“The EMS NSC [National Standard Curricula], with their detailed declarative material, limits instructor flexibility and the ability to adapt to local needs and resources. Because of reliance on highly prescriptive national standard curricula, many programs and instructors have never developed their own curricula or instructional materials. In general, EMS faculty has little experience in evaluating and using the vast array of instructional materials that are available from educational publishers.”
1.1.3 Background

There is a projected shortage of paramedic personnel qualified to provide out-of-hospital emergency medical care to the citizens of the United States. Reports of poor paramedic staffing practices appear frequently in newspapers and other media (Amrhein, 2006; Edwards, 2006; Erich, 2005; Fererri, 2006; Gray, 2005; Gruver, 2006; Olson, 2005; Todaro, 2005; Trinko, 2006). To meet the projected need for certified paramedic personnel, a sustained annual growth rate of more than 24% is required. In 2006, there were 9909 students completing their first attempt of the National Registry of Emergency Medical Technicians (NREMT) paramedic credentialing examination compared to 9551 students in 2005. This represents a growth rate of 9.6%, which is slightly higher than the average annual growth rate of 7.25% for the five-year period between 2000 and 2005 (National Registry of Emergency Medical Technicians, 2006a).

Not only is the number of paramedic students increasing at a slower rate than required to meet the demands of the public, another variable exacerbating the paramedic shortage is the low success rate of students taking the national paramedic credentialing examination. The national paramedic credentialing examination is designed to evaluate the emergency medical care provider’s ability to function independently, while providing safe and effective care in the out-of-hospital setting (National Registry of Emergency Medical Technicians, 2004). The expectation of developers of the national paramedic credentialing examination is that the student’s ability to apply knowledge gained in the classroom through various hypothetical clinical situations is a proxy measure of the student’s ability to limit morbidity and mortality in the patient population.

According to the NREMT annual report for 2006, the first-time success rate for
all individuals attempting the national paramedic credentialing examination was 62%, representing a 2% decrease in paramedic student success from the previous 12 months (National Registry of Emergency Medical Technicians, 2006a). Although recruitment of a more culturally diverse student pool has been described as a possible solution to the current and projected paramedic shortage (U.S. Fire Administration, 2007), a study by Dickison et al. (2006) indicates that, with the exception of the Asian population, ethnic minorities are significantly less likely than their nonminority counterparts to successfully complete the national paramedic credentialing examination. This suggests that simply changing the recruitment focus to include more minority populations will not effectively remedy the predicted paramedic shortage.

A possible explanation for the consistently low pass rate of students attempting the national paramedic credentialing examination is the inability to answer test questions requiring multilogic thinking. Typically, paramedic program faculty use a more traditional classroom approach in which the educator disseminates facts, rules, and policies relating to patient care and management to the student. This approach fails to provide students with opportunities to actively apply knowledge gained about these facts, rules, and policies to actual and varied patient care situations. The EMS Education Agenda for the Future (1996) calls for EMS program faculty to utilize educational theory and educational resources related to an experiential learning environment in order to help students become more adept at using facts, rules, and policies to make appropriate patient care decisions.

According to Dickison (2006) in a report presented to the NREMT Board of Directors, examination response data from students who were within 2 percentage points
of the established cut score on the examination indicated that these students were equally as likely as the population of students who passed the examination to correctly answer algorithm-based questions. However, they were significantly less likely to answer correctly if the test item required analysis and synthesis-level cognition to arrive at a correct answer. It is estimated that efforts to improve this group’s ability to effectively answer problem-based test items requiring multilogic thinking could improve overall pass rates by as much as 15% (Dickison, 2006).

An area of paramedic education that is believed to help improve student decision-making ability and success on the national paramedic credentialing examination is student participation in preceptor-observed clinical rotations and field internships (U.S. Department of Transportation 1999). Paramedic students are required to participate in both in-hospital and out-of-hospital internships designed to present the students with actual patients in the real-life environment. Prior to graduation, these students must document patient care activities involving a wide range of patients (adult, pediatric, geriatric, and psychiatric) and a variety of medical conditions (trauma, general medical, and cardiology). Preceptors, who are professionally credentialed clinicians, observe the student-patient interactions. Despite the fact that these preceptors may be physicians, nurses, or paramedics, they may not be professionally prepared educators. The amount of time spent in these student-patient interactions varies across the nation and is guided by the patient population, competitive placement, and controlled by state regulatory requirements. Although students are provided the opportunity to test and apply their knowledge to actual patients in real-life situations, experiences vary based on the patient population in the area, local resources of the healthcare agencies, numbers/types of
healthcare professions students competing for the same experience, and the policies of the local emergency medical services system. In addition to the variability of patients and resources, education of preceptors to ensure that students are provided an educational experience that promotes construction and transfer of knowledge to the clinical setting is nonexistent in the current education system.

In a joint report, the National Association of EMS Educators and the National Highway Traffic Safety Administration (Ruple, 2007) suggested that the integration of educational technologies into paramedic education programs was a possible solution to limited resources, poor decision-making ability of paramedic students, and low scores on the national paramedic credentialing examination. In response, some paramedic education programs have begun using innovative computer-based clinical simulations designed to allow students to interact with simulated patients in contextually rich patient care environments.

These interactive, computer-based clinical simulations are designed to present the student with environments and patients most commonly encountered by practicing paramedics. The standardization of patient presentations over a wide range of patient conditions may help overcome the deficiencies associated with traditional internships related to limited educational and clinical resources, resulting in reduced student-patient interactions. In addition, multidisciplinary teams of expert clinicians and education experts typically develop the patient scenarios included in these computer simulations to help ensure the patient presentation and pedagogy are appropriate and consistent to promote realism in presentation while improving pathways for knowledge construction.
1.1.4 Status

Within the paramedic community, the impact of using innovative computer-based clinical simulations to enhance a student’s decision-making ability and improve performance on the national paramedic credentialing examination has not been rigorously studied. It appears that such simulations have the potential to help paramedic students improve the quality of care given to patients, while providing faculty with additional resources to use in teaching pattern-recognition strategies necessary for transfer of knowledge and skills from the classroom to the complex patient care environment. The use of computer-based clinical simulations is promising and may provide paramedic education programs with equal or better access to student-patient interactions, improve decision-making ability of students, and ultimately result in improved performance on the national paramedic credentialing examination.

1.2 Importance of Problem

1.2.1 Significance

The high failure rate on the national paramedic credentialing examination contributes to the paramedic shortage by preventing or delaying new graduates’ entrance into the workforce. The higher failure rate results in fewer paramedics being credentialed by the NREMT to provide emergency care to the sick and injured in all geographic locations across the United States. In addition, such failures have personal and financial consequences for paramedic candidates. Unsuccessful NREMT candidates suffer the loss of potential wages that might have been earned if they were credentialed paramedics. A more nebulous, but equally costly, impact of failure on high-stakes examinations such as
the national paramedic credentialing examination is the emotional loss, characterized by feelings of inferiority, despair, and grief (Cornell, Krosnick & Chang, 2006). Vance and Davidhizar (1997) reported a similar negative emotional impact on nursing students who failed the National Council of State Boards of Nursing credentialing examination (NCLEX-RN® examination).

Not only are there financial consequences for paramedic students, the financial impact on paramedic faculty, administrators, and the prospective employer of paramedic students is substantial. A common practice in the fire service is to hire individuals as fire personnel with primary responsibilities relating to fire prevention and suppression, and then require firefighters to attain paramedic certification within a specified period of time. Firefighters, failing to gain certification as paramedics in the specified time, are dismissed from employment in the fire service. Hiring and orienting fire personnel, with the expectation of expanding their scope of practice to include paramedic care is a costly endeavor. It is estimated that the cost to train and orient fire personnel ranges from $22,445 to $72,833 per person to meet the scope of practice requirements for paramedics (Office of Budget Analyst, 2008). Failure on the national paramedic credentialing examination negates any anticipated benefit from these expenditures because these individuals cannot continue to assume the duties of fire or paramedic personnel. When considered in conjunction with the current pass rate on the national paramedic credentialing examination, this accounts for a loss of between $85,291 and $276,765 for every 10 individuals entering the orientation program.

The reputation of paramedic education programs is also affected by the poor performance of its students on the national paramedic credentialing examination. The
tarnished reputation of the program has negative self-efficacy and financial consequences for faculty. Educational researchers have identified that feelings of inadequacy and reduced motivation among faculty members are directly related to the poor performance of their students on high-stakes examinations (Abrams, Pedulla & Madaus, 2003; Behuniak, 2003). Additionally, the public’s negative view about the quality of a paramedic program with low pass rates can further degrade the self-efficacy of faculty by negatively affecting the ability of that program to recruit students. Both state and national paramedic accrediting bodies use national paramedic credentialing examination pass rates as outcome measures of program effectiveness (Committee on Accreditation of Education Programs for the EMS Professions, 2005). Programs that demonstrate a consistent pattern of low student performance on national paramedic credentialing examinations can be put on probation, placing their accredited status at risk that could ultimately result in the closure of that program.

1.2.2 Utility

The findings of this study may be useful to faculty responsible for making decisions about paramedic students’ preparedness for the national paramedic credentialing examination. The use of computer-based clinical simulations to supplement or replace costly and subjectively assessed field internships may reduce the number of national paramedic credentialing examination failures. Because of the insufficient number of individuals entering paramedic education programs and the low pass rate on the national paramedic credentialing examination, implementing tools to increase the probability of success for first-time candidates on the examination should be a top
priority of program faculty. The use of computer-based clinical simulations might provide a cost-effective, objectively measured, experiential learning environment that could play a significant role in improving certification pass rates and ameliorating the projected paramedic shortage.

1.3 Overview of the Study

1.3.1 Purpose of Study

The primary interest of this study is to test the effect (including main effects and interaction effects) of the use of computer-based clinical simulations, paramedic service type, and gender on student performance with respect to scores obtained on the national paramedic credentialing examination. The study compared two cohorts of students as they matriculated through a paramedic education program—those who used computer-based clinical simulations and those who did not use computer-based clinical simulations. Demographics relative to service type and gender were collected on each student. Each stratum of students was then compared based upon their performance on the national paramedic credentialing examination.

1.3.2 Dependent Variable

The dependent variable for this study is the score the student obtained on the first attempt of the national paramedic credentialing examination developed and administered by the National Registry of Emergency Medical Technicians. The student score is recorded as a continuous variable ranging from -3.0 to 3.0.
1.3.3 Independent Variables

Three categorical independent variables were included in this study: (1) use of computer-based clinical simulations, (2) service type, and (3) gender. Use of computer-based clinical simulations was recorded as “use” and “non-use.” Service type was recorded as “fire-based” and “non–fire-based.” Gender was recorded as “male” and “female.”

1.3.4 Other Major Variables

A covariate was included in the study. The covariate was the score the students obtained on the national emergency medical technician credentialing examination when receiving their initial credential to practice as an emergency medical technician. The student score is recorded as a continuous variable ranging from 70 to 100.

1.3.5 Research Questions

The specific research questions investigated in this study were:

1. Does the inclusion of computer-based clinical simulations within the paramedic education program have a positive effect on student performance on the national paramedic credentialing examination?

2. Does affiliation with the fire service have an effect on student performance on the national paramedic credentialing examination when compared to nonaffiliation with the fire service?

3. Does gender have an effect on student performance on the national paramedic credentialing examination?
4. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and service type on student performance on the national paramedic credentialing examination?

5. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and gender on student performance on the national paramedic credentialing examination?

6. Is there an interaction effect of inclusion of service type and gender on student performance on the national paramedic credentialing examination?

7. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program, service type, and gender on student performance on the national paramedic credentialing examination?

1.4 Definition of Terms

1. **Paramedic** - A paramedic is an out-of-hospital emergency medical care professional who is educated to respond and provide care for critically ill and/or injured individuals of all age groups. A paramedic receives a minimum of 1,000 hours of classroom-based education, supplemented by preceptor-observed clinical rotations in the traditional hospital setting and field internships in the out-of-hospital setting. Paramedics use the integration of knowledge, theory, and judgment related to anatomy, physiology, and pathophysiology to identify threats to life and limb, and they implement care based on the integration of knowledge, theory, and judgment to promote positive patient outcomes. Paramedics represent the highest level of professional credentialing within EMS.
2. **National Registry of Emergency Medical Technicians (NREMT)** - The National Registry of Emergency Medical Technicians is the nation’s credentialing agency for EMS. It offers both a cognitive and psychomotor (skills) examination process to assess an individual’s knowledge and ability to provide safe and effective patient care in the out-of-hospital environment at four distinct practice levels: (1) first responder, (2) emergency medical technician, (3) emergency medical technician-intermediate, and (4) paramedic. Its verification of competence is utilized in 50 states and 4 territories for issuance of state licensure at one, two, three, or all four credentialing levels. NREMT has gained accreditation from the National Commission for Certifying Agencies (NCCA), which is the accreditation arm of the National Organization for Competency Assurance (NOCA). NCCA accreditation indicates the standards set by the NREMT have been reviewed externally and deemed credible for ensuring the health, welfare, and safety of the public (National Registry of Emergency Medical Technicians, 2006a).

3. **NREMT National Paramedic Credentialing Examination** - The NREMT national paramedic credentialing examination is used to verify that graduates of approved paramedic education programs have met the minimal competency standards necessary for licensure. The examination consists of 80 to 150 items and has a maximum time limit for completion of 2 hours and 30 minutes. The examination is administered in a computer-adaptive format using item-response theory as the underlying scoring model. Throughout the remainder of this document, the NREMT national paramedic credentialing examination will be referred to as the paramedic examination.
4. **NREMT National EMT Credentialing Examination** - The NREMT national EMT credentialing examination is used to verify that graduates of approved emergency medical technician education programs have met the minimal competency standards necessary for certification or licensure. The examination consists of 150 items and has a maximum time limit for completion of 2 hours and 30 minutes. The examination is administered in a pen and paper format using classical test theory as the underlying scoring model. Throughout the remainder of this document, the NREMT EMT examination will be referred to as the EMT examination.

5. **Committee on Accreditation of Educational Programs for the EMS Professions (CoAEMSP)** - The Committee on Accreditation of Educational Programs for the EMS Professions is the national accrediting agency for paramedic education programs within the United States. The stated mission of CoAEMSP is “to continuously improve the quality of EMS education through accreditation and recognition services for the full range of EMS professions” (CoAEMSP, 2005). The CoAEMSP is a committee of the Commission on Accreditation of Allied Health Education Programs (CAAHEP).

6. **Computer-Based Clinical Simulations** – Computer-based clinical simulations are screen-based computer-based simulator programs, designed to provide an interactive virtual environment that allows students to immerse in a variety of areas from management and problem-based situations for the purpose of improving clinical judgment and decision making. These simulations provide students with a variety of virtual clinical experiences and patient presentations
requiring students to interact with the program software to manage the emergency scene and patient similar to how they would act in the real world. Computer-based clinical simulation programs are built on a constructivist-learning model that includes a framework for learners to build on their existing knowledge and augment existing cases they already have in their memory.

1.5 Overview of the Chapters

Chapter 1 presents the introduction to the study and provides the statement of the problem, the purpose of the study, the research questions that guide the study, and the significance of the study. Chapter 2 presents a synthesis of the related literature, previous research findings, and a conceptual framework for guiding the study design. Chapter 3 outlines an overview of the research methodology, which includes a description of the research design, data analysis procedures, and internal and external validity. Chapter 4 provides the results of the study and a discussion of the findings. Chapter 5 presents the conclusions and implications of the study findings and recommendations for further research.
Chapter 2. Review of Literature

A modicum of literature exists with reference to computer-based clinical simulation in paramedicine because the use of this technology has only recently been introduced to healthcare education. This chapter describes the conceptual basis for the development of research in this area, and specifically addresses the work of Kolb regarding typology of learning styles and experiential learning, the philosophy of Schön regarding reflective thinking using virtual practicums, and the concept of pattern recognition as a basis for improving clinical decision-making skills proposed by Elstein. The use of simulations in allied health and paramedic education will be explored as it relates the works of Kolb, Schön, and Elstein.

2.1 Kolb’s Typology of Learning Styles

Kolb’s individual learning style inventory is founded in the framework of experiential learning theory that draws on the prior work of several notable researchers in the field of human learning such as John Dewey, Kurt Lewin, Jean Piaget, and Carl Jung (Kolb and Kolb, 2005). Experiential learning is based on the following propositions supported by these notable researchers: 1) learning is best conceived as a process, not an outcome; 2) all learning is relearning; 3) learning requires the resolution of conflict; 4) learning is a holistic process of adaptation to the world; 5) learning results from synergistic transactions between person and environment; and 6) learning is a process of
creating knowledge (Kolb, 1984). Using these six propositions, Kolb developed an experiential learning model that consists of four modes: concrete experience (CE), abstract conceptualization (AC), reflective observation (RO), and active experimentation (AE). Kolb suggested the learning process represents a cycle where the learner moves through each mode in a circular or spiral progression, creating knowledge by being involved in an activity (CE), looking back critically at the activity (RO), determining what was useful or important to remember (AC), and using the information to perform another activity to confirm or invalidate the newly constructed knowledge (AE). The cycle then starts over, suggesting that experience alone does not create new knowledge; rather knowledge is constructed from the thoughts and ideas created as a result of the experience (see Figure 1).

![Kolb's Experiential Learning Cycle](image-url)

Figure 1. Kolb's Experiential Learning Cycle
Personal learning styles are an important component of the construction of new knowledge. Kolb’s typology of learning styles, which reflects different approaches to learning, emerged from this cyclical process of the four learning modes and the two continuums of grasping and transforming experiences. Kolb’s experiential learning model suggests the preference of a learner for one learning style is the combination of the individual’s preference of the grasping experience and the individual’s preference of the transforming experience within the learning cycle. Kolb describes the grasping experience as a continuum between concrete experiences (CE) and abstract conceptualization (AC). He describes the transforming experience as a continuum between active experimentation (AE) and reflective observation (RO). According to Kolb, in any learning experience, individuals are presented with situations in which they have a dominant learning preference on each continuum. They grasp experience by either feeling (CE) or thinking (AC), and they simultaneously transform experience by either doing (AE) or watching (RO).

Learning styles are defined by combining the grasping and transforming preferences of the individual. Kolb identified four learning styles that are associated with different approaches to learning: diverging, assimilating, converging, and accommodating (see Figure 2). Divergers demonstrate concrete experience and reflective observation as dominant learning modes. They are best suited for learning environments that promote problem solving within specific and defined situations. Assimilators demonstrate abstract conceptualization and reflective observation as dominant learning modes. They are most comfortable in learning situations that require the conversion of large amounts of information into concise and logical conclusions. Convergers
demonstrate abstract conceptualization and active experimentation as dominant learning modes. They excel when the learning situation calls for decision making and problem solving to a problem presentation. Accommodators demonstrate concrete experience and active experimentation as dominant learning modes. They are successful when the learning context requires active participation in real-world situations that require the application of previous knowledge in new ways to solve problems.

Figure 2: Kolb's Typology of Learning Styles

Kolb (1984) and Kolb and Kolb (2005) suggest that there are empirical relationships between learning styles and five levels of personal, educational, and occupational preferences (see Table 1).
Table 1: Relationship between Learning Styles and Five Levels of Personal, Educational, and Occupational Preferences

As indicated in Table 1, learning styles differ significantly by academic field. However, it is important to remember that this relationship is based on a numerical majority and does not suggest that an exact match of learning style and academic field is necessary or sufficient for individual success.

2.1.1 Kolb’s Learning Style and EMS Education

There have been several studies related to learning style inventories and allied health-related fields, with the majority being conducted within the field of nursing (Cavanagh, Hogan, & Ramgopal, 1995; Hauer, Straub, & Wolf, 2005). Although the results were mixed, two predominant learning modes emerged within nursing from the
various studies: concrete experience and reflective observation. This finding suggests that diverging is the predominant learning style in nursing. Among the plethora of literature on allied health care, only one study exists that investigated the learning styles of paramedics in the United States. However, because this study (Janning, 2001) consisted of a relatively small sample drawn from a single program, the generalizability of the results is questionable. A similar study in Canada (Campeau, 1998) using a larger and more representative sample suggests the predominant learning style of paramedics is converging. Assimilating, while possessing a slightly weaker statistical correlation, was also identified as a predominant learning style of paramedics. This is consistent with Kolb’s findings of a positive relationship between the field of medicine and a converging learning style. It is also consistent with Kolb’s findings of a converging learning style being positively correlated to jobs requiring technical skill and decision-making ability (Kolb and Kolb, 2005), which are characteristics of the paramedic profession. The evidence of converging and assimilating as predominant learning styles of paramedics suggests that the traditional classroom approach for the education of paramedic students may be inadequate in providing paramedic students with an optimal environment to enhance learning. On the other hand, this evidence also suggests if faculty use these findings to alter current classroom pedagogy in order to support active experimentation and abstract conceptualization students may benefit.

2.1.2 A Learning Style Model for EMS Education

A recent meeting of the National EMS Education Standards Committee resulted in a consensus that EMS education should be evaluated based on two dimensions: (1)
knowledge needed to assess and manage diverse patient presentations and (2) judgment required to make accurate patient care decisions. Using these criteria, a model has been developed and is presented in Figure 3. This model illustrates that as the complexity of patient presentations increases, the paramedic is required to use prior knowledge, experience, and theory to analyze, synthesize, and evaluate the appropriate interventions and actions. Likewise, as patient presentations become more diverse, the paramedic will require more information to recognize the presenting problems. The model demonstrates the relationship between paramedic knowledge, judgment, and the specific levels of Bloom’s cognitive domain taxonomy (Bloom et al. 1954).

Figure 3: Emergency Medical Services Learning Dimensions
Adapted from National Highway Traffic Safety Administration, 2009
Rotating the four quadrants defined by Kolb’s Learning Styles by 180 degrees and then overlaying it with the two-dimensional EMS education model, a revised learning style model can be developed which demonstrates a strong relationship between increasing knowledge, judgment, and cognitive taxonomy level required of paramedic students and the findings of Kolb and Kolb (2005) and Campeau (1998) relative to dominant paramedic student learning styles (see Figure 4).

![Figure 4: A Learning Style Model for EMS](image)

The learning style model for EMS illustrates the relationship of converging, as a dominant learning style, to paramedic students. Paramedic students who operate in an expanding set of patient presentations and approach patient care from a problem-based
perspective, integrating knowledge, theory, and past experiences to make clinical
decisions are characterized as convergers. Computer-based clinical simulations are
helpful in improving student problem-solving skills by giving them opportunity to
practice and refine thinking strategies associated with higher levels of Bloom’s taxonomy
in an environment where harm to any patient is eliminated (Gokhale, 1991; Quinn, 1993).
This learning model suggests that pedagogy and learning environments similar to those
included within the simulated patient care environments, which promote integration of
foundational knowledge and theories in various contextual patient care situations, would
be beneficial in improving paramedic student outcomes.

2.2 Clinical Knowledge Construction

2.2.1 Reflection in Action

Dewey described the process of reflective thinking as “the kind of thinking that
consists of turning a subject over in the mind and giving it serious and consecutive
consideration” (Dewey, 1933, p. 3). Thus, in reflective thinking, the individual follows a
process of examining the elements of the problem or circumstance, defining the problem,
gathering and assessing the available data, and formulating hypotheses that can be
implemented to resolve the conflict or lead to additional information, resulting in a
refined problem statement and subsequent hypothesis for testing.

Reflection-in-action, as defined by Schön (1987), is implemented by reflective
thinkers when a problem or set of circumstances does not conform to what is expected or
what is considered normal. Schön argues that clinical knowledge and decision-making
ability are not optimally built on a foundation of traditional technical rationality, which
relied on the strict application of rules, concepts, and principles to the present situation. He refers to this type of learning as knowing-in-action. Schön suggests that clinical knowledge and decision-making ability are best built on the concept of reflective thinking which requires the student to integrate rules, concepts, and principles with past experiences and actions to make decisions. He refers to this type of learning as reflection-in-action (Schön, 1987). Schön (1987) suggests that reflection-in-action is different from knowing-in-action in two distinct areas: (1) it begins in a state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates, and (2) it results in an act of searching, hunting, and inquiring, to find solutions to the perplexity of the situation.

This distinction between reflection-in-action and knowing-in-action brings into focus a significant concern of many paramedic educators: Is it possible to develop a contextually rich learning environment that is capable of successfully preparing graduates of a paramedic program for the complex and fluid world of paramedic practice? Schön’s philosophies related to reflection-in-action suggest that paramedic education could be improved by including the opportunity for students to practice making clinical decisions and refine the activities associated with reflective thinking by using the contextually rich learning environments such as those produced by computer-based clinical simulations. As a method of producing these contextually rich environments, Schön (1987) proposed the use of reflective practicums which he described as follows:

“A setting designed for the task of learning a practice. In a context that approximates a practice world, students learn by doing, although their doing usually falls short of real-world work. They learn by undertaking projects that
simulate and simplify practice. The practicum is a virtual world, relatively free of
the pressures, distractions, and risks of the real one, to which, nevertheless, it
refers. It is also a collective world in its own right, with its own mix of materials,
tools, languages, and appreciations. It embodies particular ways of seeing,
thinking, and doing that tend, over time, to assert themselves with increasing
authority” (p. 37).

Schön (1987) labels reflective practicums into three distinct categories: Type I,
Type II, and Type III. In Type I practicums, clinical knowledge and decision-making
ability is viewed in terms of facts, rules, and procedures that are applied
nonproblematically to instrumental problems. Students learn by memorizing the
necessary facts, rules, and procedures, and then applying them. The educator observes
the student’s performance, detects any errors in thought or action, and immediately
corrects the behaviors that attributed to the errors in thought or action. Type I
practicums, while providing contextually rich environments, do not necessarily promote
reflective thinking. They are closely related to the psychomotor skills exercises required
by current paramedic education programs in which students interact with a variety of
simulated and programmed patients, but are closely monitored by faculty who provide
immediate corrective action for inappropriate behavior or poor decisions, thus reducing
the opportunity for reflective thinking.

In Type II practicums, clinical knowledge and decision-making ability is viewed
as thinking like a doctor. Facts, rules, and procedures are emphasized, but they are now
applied to problematic areas of inquiry in which knowledge of the facts and rules does
not completely align with the current problems. This may require educators and mentors
to stress the rules and facts or prompt the student to invoke reflection-in-action to develop
new rules or procedures to resolve the situation. These practicums promote the use of
reflective thinking to improve clinical knowledge and the decision-making ability of paramedic students. They are closely related to the clinical rotations and field internships used in traditional paramedic education programs, where students interact with a variety of in-hospital and out-of-hospital patients under the supervision of paramedic faculty. The pedagogy of Type II practicums can be duplicated within computer-based clinical simulations to help ensure paramedic students see a greater variety of patient presentations and clinical environments while promoting reflective thinking in a safe environment.

In Type III practicums, clinical knowledge and decision-making ability is focused primarily on reflection-in-action. There is no assumption that every problem has an identifiable and applicable set of rules or a correct answer. Students have to construct new ways of defining problems, develop various plausible hypotheses, and test areas of understanding. Educators and mentors focus on the indeterminate nature of practice and emphasize the students’ reflective interaction with the variables and environment of the situation. These practicums rely primarily on reflective thinking and experiential learning to construct clinical knowledge and decision-making ability. There is no corollary for these practicums in the current paramedic education system; however, the potential for development of high-fidelity simulation systems exists and could be utilized to promote reflective thinking as the primary catalyst for construction of clinical decision-making ability in paramedic students.

The concept of reflective practicums can be adapted for inclusion within a simulation-based learning environment for paramedic education. Although not explicitly expressed by Schön, there appears to be a natural progression to the practicums, starting
with application of rules and facts to nonproblematic situations, reflecting on rules and facts as applied to problematic situations, and then forming new ways of understanding problematic situations by applying solution strategies that evolve from reflection on the rules and facts. The choice of which virtual practicum to adopt in a particular field of study is dependent on the nature of the profession and the stability of the practice environment. With respect to the EMS learning style model, it is arguable that both Type II and Type III practicums have merit in meeting the needs and complexity of the paramedic practice environment.

2.2.2 Problem-Based Learning

Faculty knowledge of medical problem solving and the reasoning process used by experienced medical personnel, such as paramedics, in the clinical setting is essential for creating a learning environment conducive to improving student learning outcomes. According to Elstein, Shulman, and Sprafka (1978), clinical problems are presented in settings where the complete set of information required to reach an appropriate solution is usually not immediately available. Hypothetico-deductive reasoning involves gathering basic contextual and assessment information from patient presentations and then generating plausible diagnostic hypotheses, based on recognition of traditional illness or injury pattern, to explain the data. As the clinician interacts with the patient and the specific environment, more information is gathered to confirm or refine the correct hypotheses and subsequently reject untenable hypotheses. Elstein et al., (1978) concluded that this type of reasoning was a key component of clinical problem solving.

Schmidt, Norman, and Boshuizen (1990) theorized that medical problem solving
involves recognition of illness algorithms and knowledge of the clinical consequences of the illness. Clinicians initially trying to understand patient presentations based on principles of anatomy, physiology, and pathophysiology demonstrate Schmidt’s concept of illness pattern recognition. Clinicians use these pathophysiological schemata to develop mental models that lead to diagnosis and patient management focused on illness or injury patterns characterized by the disease, syndrome, or trauma.

Davis, O'Brien, Freemantle, Wolf, Mazmanian, and Taylor-Vaisy (1999) found that behavioral changes in physicians were apparent with interactive continuing medical education that permitted skills practice. While no such study has been conducted in the domain of paramedicine relative to the effect of skills practice on behavioral change, the clinical problem solving and reasoning process employed by paramedics and physicians appear to be similar. These similarities suggest that the potential role of problem-based teaching systems to support long-term learning for paramedics is tenable. Elstein et al. (1978) reported that the most authentic practice environment is achieved when trained actors were a component of the simulated patient care environment. Improvements in technology have made it possible to develop computer-based simulations or virtual patients that can replace trained actors while continuing to provide a high level of realism in the paramedic-patient interaction.

Although learning theory suggests computer-based clinical simulations that enhance problem-based learning are an appropriate method of creating an enhanced paramedic learning environment, they may have deficiencies related to case specificity (Elstein, Shulman, & Sprafka, 1990; Fitzgerald, Wolf, Davis, Barclay, Bozynski, and Chamberlain, 1994). These researchers found that students may be able to perform well
on a specific patient presentation, but perform poorly on another case that has similarities. One solution proposed to overcome the problem of case specificity is to increase the number and breadth of cases assessing clinical problem-solving skills (Clyman & Orr, 1990; Melnick, 1990).

Elements of problem-based learning exist in the paramedic preceptor-directed clinical rotations and field internships involving actual practice on human beings. Typically, these experiences are completed in two settings (out-of-hospital emergency response and in-hospital) to help increase the volume and specificity of patient encounters. According to the United States Department of Transportation (1999), these clinical experiences are designed to enable the student to build a database of patient experiences that serves to help in clinical decision-making and pattern recognition in the operational setting. These experiences are conducted following, or in association with, the traditional classroom component of the education program. The opportunity for paramedic students to participate in clinical rotations and field internships has become increasingly difficult because the number of allied health students, such as nurses, respiratory therapists, midwives, and physician assistants, competing for access to clinical sites has increased. This has reduced the number of potential student-patient interactions for each paramedic student and reduced the ability of faculty to easily use this problem-based environment as an educational tool for paramedics.

When considered in terms of problem-based learning, patient simulations provide an excellent context for learning because they can provide realistic patient presentations and environments. In contrast to real patients, simulated patients do not get stressed or embarrassed, and can be available at anytime (Issenberg, McGaghie, Hart, Mayer, Felner,
Patrusa, Waugh, Brown, Safford, Gessner, Gordon, and Ewy, 1999). In addition, simulated patients have consistent and predictable behavior, which allows for a consistent and standardized experience for the student (Issenberg et al., 1999), necessary when comparison of a student’s knowledge, skills, and ability to set criterion is the desired outcome. While patient simulations involving trained actors provide the best approximation to the real paramedic-patient interaction, this form of simulation is relatively expensive to implement and may be impractical within paramedic education. A possible solution to both the reduced availability of clinical sites for actual preceptor-directed clinical rotations and field internships and the financial impracticality of using trained actors as simulated patients is the use of computer-based clinical simulations built on the principles of problem-based learning and reflection-in-action.

2.2.3 Reflective Learning and Pattern Recognition in Paramedic Education

Traditional paramedic education has been typically based on the behaviorist model of learning, which suggests that knowledge is independent of the learner and can be transferred from an educator to a learner. A contrasting view is proposed by the constructivist model of learning, which suggests that the learner builds knowledge by interacting with his or her environment in a given context. This view asserts learning optimally occurs in a realistic setting, reflecting real-world situations (Merrill, 1991, Bednar, Cunningham, Duffy, and Perry, 1995), claiming some knowledge is context dependent, and cannot be learned separate from the contextual environment (Anderson, Reder, and Simon, 1995). When viewed through the constructivist model, effective paramedic learning occurs in realistic settings that reflect real-world situations in the
Reflection is a method to promote learning in a complex and poorly defined problem domain such as medicine (Schön, 1987). It is founded in the constructivist model of learning and requires experiential learning. According to Dewey (1933), reflection requires the process of thinking or pondering about a subject to generate solutions or answers to problems. This process ultimately promotes critical thinking. The process of reflection is a critical factor in separating a technician from a clinician. Technicians tend to repeat the same experience several times in an attempt to become proficient at a skill, task, or behavior. Clinicians, on the other hand, learn from reflecting on the success or failure of previous decisions and actions based on pattern recognition in such a way that they are more apt to construct knowledge in new situations and experiences (Boyd & Fales, 1983).

Using the combination of pattern recognition and reflective thinking creates an environment that allows clinicians to continuously move back and forth between hypothesis and experimentation, which increases understanding. Optimal learning using pattern recognition and reflective thinking occurs when a combination of situation-specific environments and abstract conceptualization promote the transfer of knowledge, and thus, insight from one situation to another (Anderson et al., 1995). Educational researchers have suggested that using reflective thinking in the learning environment has tremendous utility in health professions (Schön, 1987; Shapiro & Talbot, 1991). Use of pattern recognition and reflection to create improved learning environments in paramedic education appears to possess significant merit in improving paramedic student success on paramedic examinations and subsequent practice within the profession.
Benefits of supporting reflective thinking in the education practices of paramedic students include: enhanced clinical judgment and decision-making abilities in complex patient care situations (Clouder, 2000), increased experiential learning (Atkins and Murphy, 1993), integration of theory within paramedic practice (Davies, 1995, Scanlan, Care and Udod, 2002), reduced anxiety within the learning environment (Davies, 1995), and acceptance of professional responsibility (Johns, 1995). The majority of studies exploring the outcome of reflective learning involve qualitative methods. However, a quantitative study using a treatment/post-test only design, found no significant difference in the examination outcomes achieved by students receiving reflective teaching methods compared to those receiving more traditional classroom teaching (Lowe and Kerr, 1998).

Atkins and Murphy (1993) identified five skills necessary for the successful use of reflective thinking by students in the construction of knowledge. These skills include: (1) ability to examine how a situation has affected the student and how the student affected the situation; (2) ability of the student to communicate a comprehensive account of the experience; (3) ability of the student to synthesize and integrate information; (4) ability of the student to identify existing knowledge, challenge assumptions, and explore alternatives; and (5) ability of the student to evaluate his or her new perspective. The use of reflective thinking strategies within paramedic education programs, such as computer-based clinical simulations, may have varying levels of success dependent on level attainment of these skills by students prior to implementation of the reflective-thinking strategy. Atkins and Murphy (1993) suggest development of the enabling skills for reflective thinking must be accomplished prior to implementing reflective thinking pedagogies in the classroom.
2.3 Use of Simulations in the Education Environment

Educational simulation, an outgrowth of experiential learning theory, creates a learning environment designed specifically to help motivate the learner to become actively engaged in real-world problem solving (Duffy and Cunningham, 1996; Winn and Snyder, 1996). An educational simulation is based on a real-world system or phenomena in which some elements have been simplified or omitted in order to facilitate learning. Two models of educational simulations that capitalize on the use of reflective thinking and pattern recognition as elements of the pedagogical approach are iterative and situational (Lunce, 2006). Iterative simulations are discovery focused, allowing learners to test hypotheses and observe results. Once a result is interpreted, the student is permitted to refine the specific hypothesis, alter the variables, and test the new hypothesis. Situational simulations allow students to role play to explore options and decision paths in the context of real-world problems.

Alessi and Trollip (2001) suggest that students who participate in education simulations that emulate the real world while matriculating through a course of study find the educational experience to be more intrinsically motivating than other learning modalities. The creation of virtual world environments within educational simulations allows students to operate in dangerous or expensive contexts that would otherwise be impossible or impractical in the real world. Leemkuil, DeJong, De Hoog, and Christoph (2003) found that properly prepared educational simulations provide improved transfer of learning and subsequent improved performance in real-world settings.

Although educational simulations accommodate a wide range of instructional strategies—virtual reality, laboratory simulations, case-based scenarios, and simulation
Simulations are typically more time consuming than other modes of learning because they require the learner to become immersed in problematic situations and actively experiment to reach a suitable resolution to the problem. Research has shown that without appropriate pedagogy, such as coaching and scaffolding, the learner gains little from the use of educational simulations (Heinich, Molenda, Russell, and Smaldino, 1999). In addition, research conducted by Leemkuil, et al. (2003) indicated that reflection and debriefing were critical to student success while using simulations, and in their absence, students typically interacted with a simulation as merely a game.

2.3.1 Simulations in Paramedic Education Environment

According to Ruple et al. (2005), while there are various environments where education of EMS providers is conducted, the process of providing education is fairly consistent and is typified by educators who follow a scripted lesson plan included in nationally standardized curricula. This corresponds to a traditional classroom approach, or transmission model, which emphasizes teacher-directed learning using noninteractive modes of knowledge dissemination whereby preexisting ideas are merely transmitted to the learner. Preceptor-directed clinical rotations and field internships involving practice on human beings are conducted following, or in association with, the traditional classroom component of the education program. These experiences are built on an apprenticeship model that allows students to interact directly with patients and patient care environments under the mentorship of expert clinicians. Although this apprenticeship model allows paramedics to use reflective thinking within the clinical
environment, the reduced availability of clinical sites and lack of pedagogical expertise of
preceptors, may render them less than effective in promoting optimal decision-making
ability in paramedic students. The use of computer-based clinical simulations may be an
appropriate alternative to these preceptor-directed clinical rotations and field internships
by providing varying patient care environments and complexities of injury and illness
patterns while supporting the dominant learning styles of paramedic students.

There is little literature regarding the use of simulations and student outcomes
within the domain of paramedic education. However, both general education and nursing
literature indicate that the use of simulation improves outcomes for students. According
to Medley and Horne (2005), the simulated environment provides the student with
experiential learning designed to include the breadth and depth of actual patient care
situations. In addition, these computer-based clinical simulations provide consistent
experiences for all students, allow for comparisons of student performance, and provide
the educator with critical information to assist in remediation activities following the
simulated experience. It seems reasonable to assume that the findings of the study
regarding the use of simulation in nursing education can be extrapolated and applied to
the education of paramedic students.

2.4 Virtual Patient Encounters

Virtual Patient Encounters is a computer-based patient simulation educational and
assessment product released in 2006 that provides opportunities for patient care during
the on-scene-care and care-in-transit phases of an EMS response. The student enters the
software that is packaged in the study guide, selects a patient, and engages with an initial
encounter via a video sequence that presents the student with the first several minutes of
arrival at an incident. The initial encounter (video) shows a sequence of events that are
roughly organized into: (1) EMS arrival on the scene of the incident; (2) options for
staging the emergency vehicle; (3) a panoramic view of the scene; and (4) an initial view
of an interaction with the patient(s) involved in the incident. The videos play out in real
time, with the option to pause the video player and address specific questions that an
instructor or study guide might pose to a student or class of students. The videos provide
a realistic introduction to a patient, complexities of the patient’s condition, and important
social dynamics that may be unfolding (e.g., responses of patient or patient’s family
members, interactions with law enforcement officers or other responders, and/or
difficulties communicating with the patient). The videos also provide important insight
into the physical setting of the incident that allows for discussion and analysis of scene
management, patient staging, and emergency transport decisions. The initial encounter
provides valuable information to students about potential on-scene-care and care-in-
transit options, providing an important advance organizer for subsequent work with the
patient.

From the visual and audio information received during the initial encounter, the
student enters the on-scene-care portion of the learning sequence. This is a highly
interactive learning environment that allows the student numerous opportunities for
patient assessment and intervention. At any point in time, the student can leave the on-
scene-care environment and elect to provide care-in-transit while transporting the patient
to a definitive care facility. The care-in-transit portion of the simulation provides
interactive simulation with options for assessment and intervention similar to the on-
scene-care segment. The individual scenario is completed when the patient arrives at the definitive care facility and the student transfers the care of the patient to facility staff.

A study guide accompanied the visual and audio portions of these simulations (software). Along with the textbook, the study guide and software were designed to create a learning triad that utilizes scaffolding to build on the knowledge, rules, and procedures learned in the classroom, which are then transferred to the simulated patient environment. The textbook provides the foundational knowledge about illness and injury patterns. The student is then directed to the audio and visual simulations to apply this knowledge to simulated patient scenarios. After completing a scenario, the study guide is designed to provoke the student to reflect on the scenario and his or her actions in managing the patient, thus developing problem-solving and clinical decision-making abilities. The final portion of the triad of learning is instructor-directed discourse designed to provide remediation and additional insight to students and their ability to solve problems and make correct clinical decisions.

The assessment and care functionality of the simulation is handled by a conditional logic system that allows a student to repeatedly assess the patient and implement interventions. With each assessment of the patient, the conditional logic yields the patient’s data at the moment the respective assessment was conducted. Each intervention the student implements influences the patient’s course, either positively, with no impact, or negatively, as appropriate, for that intervention in the context of the respective moment in the patient’s course. These interactive functionalities are nested within a computer interface that shows a realistic image of the patient, as well as the assessment equipment and the intervention tools, supplies, and medications that are
available in an emergency transport vehicle.

There were 15 patient scenarios identified, based on the critical tasks identified in the National EMS Practice Analysis. A multidisciplinary team of EMS professionals and educational faculty built learning maps for each patient presentation to optimize the strength of VPE software by focusing on the knowledge, skills, and abilities delineated in the National Standard Paramedic Curriculum. Virtual Patient Encounters is a direct and automated assessment of determining whether or not a student recognizes critical areas of patient care. With respect to standardization, it is conceptually similar to problem-based learning environments that use live actors. Each simulated patient encounter provides a very standardized presentation of the same cases to all students in an education program, while allowing each student the flexibility to interact within the patient care environment.

The simulation for each patient portrays a critical period in which important paramedic care decisions need to be made in order to provide the optimal care for that particular patient. The VPE system includes: (1) the conditional logic system that allows students to make intervention choices that alter, either negatively or positively, a patient’s condition; and (2) the capacity to record student choices, providing a delineation of their response patterns relative to the decisions made given the data available. The patient simulations were constructed to provide essential data that are sufficient for a clinician to recognize a pattern of assessment data, injury presentations, and/or medical signs and symptoms, thus simulating pattern recognition that has become recognized as a primary method of sound clinical judgment. These types of computer innovations provide the student with a virtual internship while overcoming the obstacles of actual internships.
2.4.1 Computer-Based Clinical Simulations

The Virtual Patient Encounters product used in this study was built on a theoretical foundation of Eldeman’s neuronal group theory (Veschure, 1993), Schön’s reflective practicum (Schön, 1987) Boisot’s epistemological space (Boisot, 1995), and Kolb’s learning cycle (Kolb, 2005)

2.4.1.1 Theory of Neuronal Group Selection

Gerald Edelman proposed the theory of neuronal group selection, which has the underlying assumptions that (1) the world is structured; (2) neural development is an evolutionary process guided by natural selection; and (3) phenomenal experience exists in conscious persons (Veschure, 1993). Edelman theorizes the brain consists of neurons and neuronal groupings that develop structure and function based on an evolutionary process during interaction with the structured world. These neuronal networks, through interaction with external stimuli, result in patterns of input perceptions and output signals in response to different situations. As these neuronal networks compete, the result is the development of repertoire or schema that deal most effectively with the current situation. This process of perception and categorization continues to evolve, allowing primary repertoire or schema to combine to form more categorizations permitting the professional to explain and operate in his/her uncertain and complex world.

2.4.1.2 Schön’s Reflective Practicum

Schön (1987) coined the term reflection-in-action to describe the process of knowledge construction when real-life situations do not conform to the boundaries of
what an individual has learned to consider normal. Schön suggests that when an
individual encounters a situation that does not conform to permit the use of learned facts,
rules, and processes for resolution, the individual implements reflective thinking to
critically examine the situation and gather real-time information to reframe the problem.
This process may permit the individual to use prior experiences and neuronal schema to
construct new and innovative solutions or may result in additional cycles of reflective
thinking until an acceptable solution is achieved.

Schön suggested decision making and clinical judgment abilities of healthcare
providers could be improved through practicing reflective thinking and reflection-in-
action. He advocated the use of reflective practicums within the educational process to
allow students the opportunity for such practice. He described the virtual practicum as a
virtual world free of the risks and distractions of the real world to which it represents.
Students immersed in the virtual practicum engage in the operations, thoughts, emotions,
and complexities of the discipline in which they aspire to practice under the guidance of
expert practitioners. These expert practitioners, at times, teach in a conventional manner
ensuring the dissemination of facts, rules, theories, and examples of clinical practice.
However, the main function of the expert practitioner is to demonstrate, advise, question,
and critique.

The Virtual Patient Encounters product is directly related to this description of
Schön’s virtual practicum by using a computer-generated emergency medical
environment in which the paramedic student can immerse and practice reflective thinking
and reflection-in-action.
2.4.1.3 Boisot’s E-Space and Kolb’s Learning Cycle

Max Boisot (1995) developed a framework for understanding a concept he termed the epistemology space (E-Space), which he suggests provides a model for better understanding of what is included in comprehensive clinical education. Boisot combines the framework of the E-Space with Kolb’s (2005) learning cycle to suggest how technology may be leveraged to facilitate improved decision making and clinical judgment by healthcare practitioners.

Figure 5 is a representation of Boisot’s E-Space using a two-dimensional model to describe the components of knowledge construction related to experiential learning theory. The vertical axis represents the perceptual continuum and consists of sensory stimuli perceived by an individual ranging from uncoded to highly coded. Uncoded sensory stimuli are described as a sensory stimulus or a combination of sensory stimuli that are new to the individual. Coded stimuli are described as preprocessed stimuli, such as words or symbols, which are familiar to the individual from prior learning. The horizontal axis represents the conceptual continuum and ranges from concrete to abstract. Concrete concepts include specific situations that adhere to established facts, rules, and processes. Abstract concepts include less specific situations but relate to general and universal principles of the discipline. The important difference between the perceptual and conceptual continuums is that the perceptual continuum originates in actual stimulation of the five senses, while the conceptual continuum depends on stimulation of memory and schema developed from past experiences.

The upper regions of the E-Space model represent knowledge that is derived from fact, rules, theories, and processes. This region of thought and action is rational and
stable, and is generally unaffected by the complexities and variability of real-world situations. The lower region represents the knowledge that is necessary for Schön’s reflection-in-action. This region of thought and action is related to an individual’s ability to sense, understand, act, and grasp meaning from being actively engaged in complex real-world situations. The ability to rapidly and accurately determine which elements and interactions of stimuli, both perceptual and conceptual, are important to good clinical judgment. According to Boisot (1995), while abstract concepts provide a venue for discussion and discourse about clinical judgments, it is through the richer context of concrete experience that a student practices and learns the skills of decision-making and clinical judgment.

Figure 5: Boisot’s E-Space
*Adapted from Boisot, 1995*
Boisot used Kolb’s learning cycle to make a direct link between learning and the E-Space. In Kolb’s (1984) experiential learning model, a student’s experiences are transformed into abstract concepts, which through a process of reflective observations, are translated into new experiences. This cycle is then repeated with each successful new experience, resulting in the development or refinement of neuronal group schema that persist as knowledge in the E-Space. Kolb divides this learning cycle into four quadrants that he defines as learning styles and, according to Boisot (1995), correlates to the quadrants of the E-Space. To become an expert clinician with mature decision-making skills, Boisot suggests integration of all learning styles is essential. From an educational perspective, this requires providing learning environments and experiences that promote all four learning styles. The use of a single pedagogy or learning situation focuses on only one area of the E-Space and limits construction of new knowledge necessary for improving decision making and clinical judgment. In most paramedic education programs, the learning pedagogy and experiences are situated in the upper two quadrants of the E-Space that represent technical and scientific knowledge. This results in limiting the paramedic’s potential for growth in decision-making and clinical-judgment skills, not necessarily because of the student, but because the design of the learning experience fails to integrate the entire E-Space.

Computer-based clinical simulations, such as the Virtual Patient Encounters product, build on the foundations of Kolb’s experiential learning cycle to develop a computer-based virtual practicum by incorporating the entire E-space in the learning experience, thus optimizing the learning potential of the students. A key element of computer-based clinical simulations is provision of a virtual environment representative
of the clinician’s practice environment with appropriate complexity and sufficient realism to simultaneously stimulate the upper and lower regions of the E-Space, thus increasing educational efficiency and effectiveness.

2.5 Decision Making and Clinical Judgment

2.5.1 Critical Thinking and Problem Solving

Paramedic literature has not focused on an appreciation of critical thinking as a complex process. Historically, paramedic education has focused on outcomes, such as problem solving and decision making, which are often considered synonymous with critical thinking. However, there is an essential difference between problem solving and critical thinking. Paramedic problem solving focuses on a specific patient or emergency scene problem, such as a multisystem trauma or a mass casualty situation, and ultimately finding solutions to resolve the specific problem. According to Meyers (1991), critical thinking does not seek a specific solution to a problem, but rather aims to raise questions about the problem and evaluate the possible solutions. Chenworth (1998), Facione, Facione and Sanchez (1994), and Paul (1990) indicate that critical thinking includes elements such as active argumentation, reasoning, application, analyzing complex meanings, identifying problems and considering alternative solutions. These researchers suggest that critical thinking is a process that promotes continuous exploration, redefinition, and understanding, which contribute to a process of reasoned interaction between a person and a situation or environment. Bittner and Tobin (1998) describe the critical-thinking process “similar to an umbrella under which many types of thinking flow, depending on the situation” (p. 269). An important step in problem solving and
decision-making is the use of critical-thinking abilities to reframe a problem or situation in order to make decisions about appropriate problem resolution. Facione and Facione (1993) describe critical thinking as a cognitive engine that drives problem solving and decision-making.

2.5.2 Critical Thinking and Decision Making

Decision-making in paramedicine focuses on the clinical nature of a problem situation. It includes a reasoned and systematic process of assessment, analysis of potential diagnoses and interventions, evaluation, and judgments that will result in the desired patient outcome. Bittner and Tobin (1998) affirm that when cognitive knowledge and experiential knowledge of the clinician interact, “the outcome is a clinical decision-making process that embraces critical thinking” (p. 269). Bittner and Tobin (1998) suggest incorporating critical-thinking skills during the decision-making process results in clarification of data, potential solutions focused on the intended outcome given the complexity of the situation, and reasoned support for the clinical decision.

2.6 Measurement of Decision Making and Clinical Judgment

The NREMT incorporates clinical judgment and decision making as a concept within the design of each version of the paramedic examination. Morrison and Free (2001) and Morrison, Smith, and Britt (1996) described a model for multiple-choice test item writing that is used to construct NREMT national credentialing examinations. This model consists of three rules that test writers must follow when creating items for use in all NREMT national credentialing examinations: (1) write questions at the application
cognitive level or above; (2) require multilogical thinking to answer questions; and (3) require a high level of discrimination to choose from among plausible alternatives. The first criterion of the test-writing model refers to the focus of test items on applying paramedic concepts. This criterion reflects the application of Bloom’s (1956) taxonomy, a system that assists educators in defining cognitive domains of learning (Sax, 1997). Morrison et al. (1996) stated that critical-thinking test items cannot be effective if they are written to only evaluate learning at the lower levels of the cognitive domain that are characterized by rote memorization. Instead, these items should be written at a higher cognitive level, using verbs that reflect knowledge at the application level (and above) of the taxonomy.

The second criterion of the test-writing model refers to the use of multilogical thinking, a type of thinking described by Morrison and Free (2001) and Morrison et al. (1996) that is based on critical-thinking theory to answer test items. Students must know more than one concept or fact to successfully answer critical-thinking test items. If only one fact or concept was needed to determine the correct answer, the student would only be employing memorization, which implies development of the test item at the lower level of Bloom’s taxonomy. However, multiple concepts must be linked together to create a multilogical-thinking test item, and Morrison et al. (1996) suggested that the preferred method for challenging students to make decisions and clinical judgments in answering these test items involves the application of several paramedic concepts in a clinically oriented situation.

The third criterion of the test-writing model involves incorporation of a high level of discriminating judgment to answer the test question. Morrison et al. (1996) suggested
that test item writers only use plausible alternatives to construct item distractors, implying that while all answer choices could conceivably be possible, only one is actually better than the others (i.e., with “best” defined as “most important, first, highest priority, and so forth…” (p. 20)). The use of highly discriminating, plausible alternatives when constructing multiple-choice tests promotes decision making and clinical judgment among students. A sample of paramedic items reflecting the decision making and clinical judgment included on the national credentialing examination are presented in Appendix A.

2.6.1 The NREMT Paramedic Examination

The purpose of the NREMT paramedic examination is to assess the candidate’s knowledge and skills for competent practice as a paramedic. It is a criterion-based examination rather than a norm-based examination. Unlike a norm-based examination that ranks an individual and tests achievement, a criterion-based examination assesses an individual’s competency based on a predetermined standard. Candidates taking the examination are not in competition with others but must simply demonstrate they have the knowledge and skills necessary to make appropriate decisions and clinical judgments to provide safe and effective paramedic care in a variety of complex patient presentations.

The paramedic examination consists of items drawn from the National Registry’s paramedic item bank, following a test plan, and administered in a computer-adaptive testing format. This test plan is developed based on the result of the paramedic practice analysis that is conducted every five years. The paramedic examination includes only items that reflect paramedic practice and is independent of all other examinations.
developed and administered by the NREMT. It is not designed to measure foundational knowledge and skills attained by students who have attained lower levels of EMS credentialing, such as EMT. The NREMT surveys practicing paramedics who are asked about the importance, difficulty, and criticality of tasks they perform with respect to patient morbidity, mortality, and safety. The results of the data are reviewed and analyzed by a committee of national experts, including representation from the physician, nursing, and paramedic disciplines, as well as representation from the research and psychometric communities. The results of the committee are presented to the Board of Directors of the NREMT and used to develop a test blueprint designed to measure the paramedic student’s ability to provide safe and effective care in the out-of-hospital environment. State EMS licensing offices use the results of the examination as part of the process for issuance of the right to work within the state as a paramedic.

Test items are prepared by item-writing committees that consist of ten to twenty EMS experts, including physicians, nurses, and paramedic faculty. Items are reviewed, rewritten, and reconstructed following input from the NREMT staff and a psychometrician. Items successfully emerging from the item-writing process are then pilot tested throughout the United States using paramedic students who have successfully completed the paramedic program but have not attempted the current paramedic examination. Following the pilot test, an item analysis is conducted, and only those items that are psychometrically sound and functioning properly are added to the live item bank.

2.6.1.1 Paramedic Examination Standard-Setting Process

The NREMT convened panels of physicians, regulators, and paramedics to
conduct a modified Angoff standard-setting process (Angoff, 1971) to establish the passing standard for the NREMT paramedic examination. Items chosen for the standard setting of the paramedic examination were field tested, calibrated, and scheduled for use in the NREMT computer-administered paramedic examinations. The items selected for the standard-setting process were chosen to meet the test plan specifications approved by the NREMT Board of Directors and closely paralleled the distribution of item difficulties on the current paramedic examination. A total of 110 items were chosen. NREMT content staff carefully reviewed each of the items beforehand to ensure that the items represent valid content to be tested and to make certain that the items were keyed correctly and had no typographical or grammatical errors.

Eleven judges were selected by the NREMT staff to represent a diverse sample of paramedic practice throughout the United States. The judges were selected from a variety of regions, work settings, ethnicities, gender, and years of experience.

The standard-setting session opened with a description of the purpose and process of standard setting, a discussion of the judges’ understanding of the minimally competent paramedic, and a practice session consisting of 12 items that served to familiarize judges with the details of the standard-setting process. The practice session included rating items, feedback of data, and group discussions for each item.

The first portion of each session was devoted to a detailed discussion of the practice of the paramedic and a detailed characterization of the group’s understanding of minimal competence as it relates to entry-level practice. The NREMT psychometrician led this part of the session with input from NREMT staff. Based on the discussion of the minimally competent paramedic, the group came to an agreement on the concept of the
minimally competent entry-level paramedic candidate.

For each item, the judges were instructed to ask themselves, “How many minimally competent paramedic candidates, out of 100, would answer this item correctly?” Judges read and rated a batch of items at their own pace and then joined in a group discussion of the items and the judges’ ratings. During the group discussion, judges were provided a feedback summary showing each of the judges’ ratings and a minimum, maximum, and mean rating for each item. The feedback also provided an estimated difficulty for each item that was based on the estimated proportion correct at the approximate cut score. This estimated difficulty was on the same scale as the judges’ ratings and enabled judges to compare their own ratings with candidate performance to bring a reality check into the rating process. Judges were encouraged to provide rationale for their ratings, particularly judges with the highest or lowest ratings for each item. Group discussions focused especially on items that had a wide range of ratings, or items that had a large difference between the judges’ mean rating and the estimated difficulty of the items. Following the group discussion of each item, judges were instructed to reconsider their own rating of the item using any new information or points of view from the group discussion and item data feedback. After reconsideration of the first rating, the judges were instructed to give a final rating for each item that was used to calculate the passing standard results.

At the end of the session, judges were asked to answer six supplemental questions that were used to provide another perspective on the judges’ ratings of the passing standard. Judges were asked: 1) What is the lowest acceptable score, even if no student attained that score? 2) With this cut score, what do you expect the passing rate to be? 3)
What is the highest acceptable cut score, even if every student attained that score? 4) With this cut score, what do you expect the passing rate to be? 5) What is the maximum acceptable failure rate? 6) What is the minimum acceptable failure rate? These questions were used to provide an alternative to the modified Angoff passing standard, namely the Beuk compromise procedure (Beuk, 1984; Breyer, 1993).

This process produced a mean percentage correct for each item based on the judges’ collective understanding of the minimally competent paramedic candidate. The mean of all item ratings produced an overall percentage correct for the items that were rated. This overall mean can be interpreted as the percentage of the items that the judges would expect the minimally competent candidate to answer correctly. In other words, this overall mean represents the new passing standard.

After joint consideration of the historical experience of past standard-setting panels and the current recommendations of the Angoff panel relative to national pass rates, the NREMT Board of Directors selected the mean passing percentage recommended by the Angoff panel, which translated into a theta value of 1.25 (National Registry of Emergency Medical Technicians, 2006b).

2.6.2 The NREMT EMT examination

The purpose of the NREMT EMT examination is to assess the candidate’s knowledge and skills for competent practice as an EMT. Similar to the paramedic examination, it is a criterion-based examination, but consists of items drawn from the National Registry’s EMT item bank and administered in a traditional pen and paper format. The test plan for the EMT examination is developed based on the results of the
EMT practice analysis and includes only items that reflect EMT practice. It is independent of the paramedic examination and development procedures ensure no items included on the EMT examination will appear on any other level of national credentialing examinations developed and administered by the NREMT.

The EMT examination is developed using a process similar to that used for development of the paramedic examination, including the use of a practice analysis to identify importance, difficulty, and criticality of EMT tasks with respect to patient morbidity, mortality, and safety. The practice analysis committee includes representation from the physician, nursing, and EMT disciplines, as well as representation from the research and psychometric communities. As with the paramedic examination development process, the Board of Directors of the NREMT use the results of the committee to develop a test blueprint designed to measure the EMT student’s ability to provide safe and effective care in the out-of-hospital environment. State EMS licensing offices use the results of the EMT examination are used as part of the process for issuance of the right to work within the state as an EMT.

The development of test items follows the process used to develop paramedic items, with the exception that EMT faculty are included on the item-writing team and paramedic faculty are excluded. Pilot testing of items throughout the United States is conducted using EMT students who have successfully completed the EMT program but have not attempted the current EMT examination. Following the pilot test, an item analysis is conducted, and only those items that are psychometrically sound and functioning properly are added to the live item bank.
2.6.2.1 EMT Examination Standard-Setting Process

The NREMT convened a panel of EMS experts and used the Gross Modification of the Nedelsky Procedure (Gross, 1985) to establish the pass/fail score for the EMT examination. The items chosen for the standard setting of the EMT examination were field tested and chosen to meet the test plan specifications approved by the NREMT Board of Directors. A total of 150 items were chosen. NREMT content staff carefully reviewed each of the items beforehand to ensure that the items represented valid content to be tested and to make certain that the items were keyed correctly and had no typographical or grammatical errors.

Twelve judges were selected by the NREMT staff to represent a diverse sample of EMT practice throughout the United States. The judges were selected from a variety of regions, work settings, ethnicities, gender, and years of experience.

The standard-setting session opened with a description of the purpose and process of standard setting, a discussion of the judges’ understanding of the minimally competent EMT, a discussion of the difference between a sophisticated and nonsophisticated distractor, and a discussion of criticality versus noncriticality as it relates to various aspects of EMT care in a variety of complex patient situations. A sophisticated distractor was defined as a distractor that, in the combined opinion of the judges, may reasonably cause the minimally competent EMT student to choose it. A nonsophisticated distractor was defined as distractor that, in the combined opinion of the judges, would not be chosen by a minimally competent EMT. Items were considered critical, if in the combined opinion of the judges, a selection of any distractor over the correct answer would result in harm to the patient or the EMT in an operational setting.
Each item was presented to the judges and they were instructed, as a group, to identify the correct answer and label each distractor as sophisticated or nonsophisticated. Each correct answer was given a value of 2, each sophisticated distractor was given a value of 1, and each nonsophisticated distractor was given a value of 0. In addition, regardless of sophistication, any distractor identified as potentially harmful to the patient or EMT was given a value of 0. The results for each item were then inputted into the following formula to determine the item multiple passing indices (Gross 1985).

\[
\frac{\text{Weight of Correct Response}}{\text{Sum of all Option Weights for Items}} - \frac{1}{k (\text{sum of option weights})}
\]

Equation 1: Gross Modification of the Nedelsky Formula

where the weight of the correct response is equal to 2 and \( k \) is set equal to 5, which according to Gross (1985) will create an upper and lower bound for multiple passing indices of .90 and .30 respectively. An example of the application of the Gross Modification of the Nedelsky formula is presented in Appendix B.

This process produced multiple passing indices for the items included in the EMT examination. The mean of all multiple passing indices produced an overall percentage correct for the items that were rated. This overall mean can be interpreted as the percentage of items that the judges would expect the minimally competent EMT student to answer correctly. In other words, this overall mean represents the passing standard for the EMT examination.

After joint consideration of the historical experience of past standard-setting
panels and the current recommendations of the Nedelsky panel relative to national pass rates, the NREMT Board of Directors established a passing standard of 70% for the EMT examination (National Registry of Emergency Medical Technicians, 2006b).

2.7 Paramedic Service Type

Paramedic service within the United States is approximately divided equally among fire-based and non–fire-based services (Institute of Medicine, 2006). While both fire-based and non–fire-based paramedics respond to similar patient care settings and are required identical patient care education, there are frequently conflicts between these two cohorts of emergency responders (Davis, 2004). These conflicts between professionals in a single discipline suggest there may be differences between the organizational climate of fire-based and non–fire-based paramedic service types. According to Davis (2003), while the scope of practice of the paramedic is the same regardless of service type, the organizational climate within the service types differ. Non–fire-based systems are focused primarily on medical care, while fire-based systems are focused primarily on rescue operations and fire suppression. Davis (2003) concludes that these differences in organizational climate result in unique differences between paramedics who affiliate with non–fire-based systems and those who affiliate with fire-based systems. Utilizing Herzberg and Mausner’s Motivation-Hygiene Theory, Patterson, Warr, and West, (2004) demonstrated a significant correlation between organizational climate and a variety of employee demographics, including satisfaction and motivation. Millin and Levine (2008), analyzed 10 years of longitudinal data related to paramedic demographics and concluded that paramedics affiliated with a fire-based service were significantly more
likely to continue service within the profession than those paramedics affiliated with non–fire-based services. Salaries for EMS providers are traditionally higher in fire departments and some fire departments require success on the paramedic examination for continued employment and/or promotion (Brown et al., 2002; Monasky, 2002; HealthAnalytics LLC, 2001). Dickison et al. (2006) reported a significant difference in paramedic examination scores between fire-based and non–fire-based paramedics, suggesting a difference in these populations with respect to student outcomes following paramedic education. The finding of these researchers may suggest that extrinsic motivators, such as salary and continued employment, associated with fire-based paramedic service are having an impact on success rates relative to the paramedic examination.

2.8 Paramedic Gender

Primary and secondary education literature is replete with studies indicating gender differences related to performance on academic examinations. The majority of this research has indicated that males typically score higher on mathematic and science academics than females (Mullis, Martin, Fierros, Goldberg, and Stemler, 2000; Bellar and Gafni, 1996; Hyde, Fennema, and Lamon, 1990; Lumis and Stevenson, 1990; Benbow, 1988). A predominant portion of paramedic education is built on knowledge of anatomy, physiology, pathophysiology, and pharmacology, which include mathematics associated with the administration of emergency medications. This suggests that gender differences identified by these researchers may be present in the paramedic examination that is designed to measure student attainment of paramedic competence.
Some researchers have used Bandura’s (1977) self-efficacy theory to suggest that a portion of the gender differences can be attributed to low self-esteem among females. Using the theoretical underpinnings of the self-efficacy theory, Hackett and Betz (1981) identified gender gaps with respect to results in male-dominated careers, such as paramedicine. Using a multivariate logistic regression model and a sample of 5208 paramedic students, Fernandez et al. (2008) identified gender as a significant variable, predicting the probability of passing the examination. In a similar study of medical students attempting the United States Medical Licensing Examination (USMLE), Lynch, Whitley, Emmerling, and Brinn (2000) identified gender as a significant predictor of preparedness for USMLE content.

2.9 Relationship between Paramedic and EMT Practice

The current EMS credentialing system includes two prominent levels of education credentialing: emergency medical technician (EMT) and paramedic. While these two levels operate within the EMS system, they are independent levels of patient care providers. The EMT is a technician while the paramedic is considered a clinician. The EMT is considered a technician who assesses patients to identify threats to life and limb, and implements patient care to reduce mortality and loss of limb, based on established protocol/treatment algorithms. In complex patient presentations, the EMT alters protocol/treatment algorithms based on integration of assessment findings and input from higher-level trained providers, such as paramedics. The paramedic is considered a clinician who assesses patients to identify threats to life and limb, and implements care based on the integration of knowledge, theory, and judgment related to anatomy,
physiology, and pathophysiology to reduce morbidity and mortality and promote positive patient outcomes.

Fernandez and Studneck (2009) analyzed the relationship between the NREMT EMT examination score and success on the paramedic examination. The sample included first attempt paramedic scores from 2002-2006 in the 14 states that utilize NREMT credentialing examinations for initial certification of both EMTs and paramedics. An individual’s score on the EMT examination was significantly associated (p=0.38) with success on the paramedic examination, accounting for 14.44% of the variance associated with a student score on the paramedic examination. These findings suggest it may be appropriate to control for this systematic variance in studies using student scores on the paramedic examination as a dependent variable.

2.10 Summary and Conceptual Framework

The allied health literature indicates there is an impending paramedic shortage in the United States exacerbated by a 32% failure rate on the paramedic examination. Dickison (2006) asserted improving paramedic student clinical-judgment and decision-making abilities could improve the paramedic pass rate on the credentialing examination by as much as 15%. Kolb and Kolb’s (2005) typology of learning indicates that paramedic students’ dominant learning style is converging and they prefer learning environments that permit them to use abstract conceptualization and active experimentation as grasping and transforming experience to enhance construction of knowledge. The EMS education model supports converging as a dominant learning style of paramedic students and indicates the improved decision-making ability of paramedics
is necessary for success of these students. Schmidt et al. (1990) indicate that clinical decision-making ability of paramedics relies on pattern recognition of a variety of illnesses and injuries, and Elstein et al. (1978) indicate paramedic decision-making ability is improved by using a pedagogy based on problem-based learning. The constructivist’s concept of learning and Schön’s (1987) concept of learning by reflection-in-action suggest a paramedic’s knowledge construction is enhanced by environments that support an expanding set of patient presentations and approach patient care decisions from a problem-based perspective. Schön recommends the use of a reflective practicum in the form of high-fidelity patient simulators and computer-based clinical simulations to enhance reflective thinking, problem solving, and clinical decision making in complex situations.

The EMS educational model, Schön’s reflective practicum, and the ability of computer-based clinical simulations to enhance experiential learning form the basis of the conceptual framework for this study. The conceptual framework suggests using computer-based clinical simulations that are built on concepts of reflection-in-action and problem-based education will enhance the clinical decision-making ability of paramedics through experiential learning, and will improve outcome on the paramedic examination.
Chapter 3: Design and Method

3.1 Research Purpose

The primary interest of this study was to test the effect (including main effects and interaction effects) of the use of computer-based clinical simulations, paramedic service type, and gender (independent variables) on student performance with respect to scores obtained on the paramedic examination (dependent variable). The study compared each stratum of students as they matriculated through a paramedic education program, based upon their performance on the paramedic examination.

The study included one dependent variable, three independent variables, and one covariate. The dependent variable for this study is the score the student obtained on the first attempt of the paramedic examination developed and administered by the National Registry of Emergency Medical Technicians (NREMT). Three categorical independent variables were included in this study: (1) use of computer-based clinical simulations; (2) service type; and (3) gender. Use of computer-based clinical simulations was recorded as “use” and “non-use.” Service type was recorded as “fire-based” and “non–fire-based.” Gender was recorded as “male” and “female.” A covariate was included in the study. The covariate was the score the student obtained on the national emergency medical technician (EMT) credentialing examination when receiving the initial credential to practice as an EMT.

Specific objectives of this study were to discover whether there are differences in
scores obtained on the paramedic examination, after controlling for scores obtained on the EMT examination, associated with use of computer-based clinical simulations, paramedic service type, and gender. In addition, the study investigated whether changes in the student scores over one level of independent variable were dependent upon the levels of the other independent variables. Accordingly, this research study was designed to investigate two-way and three-way interactions among the independent variables, as well as the main effects of these variables.

A secondary purpose of this study was to investigate how faculty used computer-based clinical simulations to determine if coaching, scaffolding, debriefing, and remediation pedagogies were utilized in conjunction with the computer-based clinical simulations. A focus group of paramedic educators was convened to investigate the following specific issues: (1) usability of the computer-based simulation product; (2) integration of the computer-based clinical simulations within the paramedic educational environment; and (3) perceived effectiveness of the computer-based clinical simulations in improving students’ decision-making and clinical-judgment abilities.

In this chapter, research design, population, sample, intervention, instrumentation, data analysis, assumptions, and limitations are discussed.

3.2 Overall Study Design

The current study, a causal comparative design, used a three-way ANCOVA factorial design, where two levels of usage (use and non-use) of Elsevier’s Virtual Patient Encounters (VPE), two levels of gender (male and female), and two levels of work environment (fire-based and non–fire-based) represent the independent variables. The
dependent variable was the student score on the paramedic examination, while the
covariate was the student score on the EMT examination. The scores achieved by the
study participants on the paramedic examination, a continuous variable distributed on a
logit scale ranging from -3.00 to 3.00, were provided by the NREMT. The passing score
on the EMT examination was provided by the NREMT registrant database. This variable
is continuous and is represented by a scoring scale ranging from 70 to 100. The lower
limit of the scale is attenuated because it represents the lowest possible score resulting in
passing the EMT examination. Only individuals who passed the national EMT
credentialing examination were eligible to attempt the paramedic examination.

3.3 Study Target Population
The target population for this study was paramedic students who successfully
completed a nationally or state accredited paramedic education program and completed
an initial attempt of the paramedic examination between the inclusive dates of July 1,
2007 and June 30, 2008. Table 2 presents the work environment and gender distribution
of the paramedic testing population for the 5 years prior. These numbers are presented to
determine the relative stability of the population to ensure generalizability of the sample
to the target population.
The values in table 2 indicate an increase (16.8%) in the number of paramedic students attempting the national paramedic credentialing examination over the time period of 2003 - 2007. The predominant gender within the paramedic student population is male (75.51% - 77.43%) and slightly more than half of the paramedic student population reported non-fire service as their service type (50.94% - 58.50%). There has been a steady decrease in the number of fire service paramedics over the 5 year period however in each year there are more non–fire-based paramedics than fire based paramedics.

Because the study investigates the interactions of service type and gender with respect to national paramedic credentialing examination scores, the distribution of gender within the fire service in the target population is presented in table 3.
<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number Career Firefighters</td>
<td>258,000</td>
<td>268,000</td>
<td>243,000</td>
<td>253,000</td>
<td>288,000</td>
</tr>
<tr>
<td>Percent Male Career Firefighters</td>
<td>96.6%</td>
<td>94.8%</td>
<td>96.7%</td>
<td>96.4%</td>
<td>94.8%</td>
</tr>
<tr>
<td>Percent Female Career Firefighters</td>
<td>3.4%</td>
<td>5.2%</td>
<td>3.3%</td>
<td>3.6%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

*Accurate figures on volunteer firefighters are difficult to obtain. The International Association of Women in Fire and Emergency Services (2008) estimate that 35,000-40,000 women are in the volunteer fire service in the U.S. This accounts for between 4.2% and 4.8% of the 825,450 individual firefighters who reported their work status as “volunteer” in 2007 (NFPA, 2008).

Table 3: Five Year Career Firefighter Distribution by Gender*

The values in table 3 indicate there has been a 10% increase in the total number of career firefighters during the 5 years prior to the study. The gender distribution within the fire service is more male dominated (94.8% - 96.7%) than the total population of paramedic students. Conversely, the fire service represents between 3.4% and 5.2% of female fire-based paramedics, while females represent approximately 23% of non–fire-based paramedics.

3.4 Study Sample

A convenience sample was used for this study that included all paramedic students who completed a first attempt of the paramedic examination between the inclusive dates of July 1, 2007 and June 30, 2008. Exclusion criteria includes: (1) individuals testing before July 1, 2007 or after June 30, 2008; (2) individuals who did not complete the EMT examination prior to July 1, 2007; and (3) individuals who attempted the paramedic examination during the inclusive dates, based on completion of a program of education in medicine or nursing.
The VPE groups were determined using the 2007–2008 sales records of the developer of the VPE software program. Paramedic programs that purchased the software for use during the 2007 academic and testing year were included in the VPE user group. A telephone call was made to each program to confirm their purchase and use of the program during the 2007 academic year. Paramedic programs not included in the sales report were considered nonusers of VPE.

Gender and work environment were determined based on data provided by the student to the NREMT upon completing the application for the national paramedic certification examination. With respect to gender, the application allowed for students to indicate gender as male or female. Individuals leaving this section blank on the application were omitted from the study. With respect to work environment, the application allowed students to choose fire-based, hospital-based, private, or government. Based on previous research (Dickison et al., 2006) suggesting individuals in fire-based work environments perform differently relative to outcomes on the national paramedic certification examinations, the categories were collapsed. For the purposes of this study, individuals indicating they worked within the fire service were categorized as fire-based while all other individuals were considered non–fire-based.

The passing score on the EMT national credentialing examination was provided by the NREMT registrant database. This variable is continuous and is represented by a scoring scale ranging from 70 to 100. The lower limit of the scale is attenuated because it represents the lowest possible score resulting in passing EMT national credentialing examination. Only an individual who passed the EMT national credentialing examination was eligible to attempt the national paramedic examination. Individuals not
successfully completing the EMT national credentialing examination were omitted from the study.

The score achieved by the study participants on the NREMT paramedic credentialing examination were provided by the NREMT. This is a continuous variable distributed on a logit scale ranging from -3.00 to 3.00.

The NREMT provided 5966 student records containing responses to the three independent variables. The distribution of student records to each analytic cell of the factorial ANOVA design is presented in table 4.

<table>
<thead>
<tr>
<th>Gender</th>
<th>VPE Usage</th>
<th>Non VPE Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fire Service</td>
<td>Non Fire Service</td>
</tr>
<tr>
<td>Male</td>
<td>314</td>
<td>257</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td>143</td>
</tr>
</tbody>
</table>

\[ n = 5966 \]

Table 4: Cell Sample Sizes for VPE x Service Type x Gender

The sample included 743 (13%) paramedic students who utilized the Virtual Patient Encounter software to supplement traditional paramedic education compared to 5223 (87%) who did not utilize the computer-based clinical simulation software. According to sales records provided by the developer of VPE, this is similar to the 15% of the target population who purchased the VPE software during the study period.

The sample included 2547 (43%) paramedic students who indicated service type as fire and 3419 (57%) who indicated non-fire as their service type, which is similar to...
the target population distribution of 50.94% to 58.5% who describe themselves as non-fire-based paramedics. Of the 743 VPE users, 343 (46%) indicated service type as fire and 400 (54%) indicated service type as non-fire. In addition, the sample included 5223 non-VPE users, 2204 (42%) who indicated service type as fire and 3019 (58%) who indicated service type as non-fire. This distribution of service type by VPE usage is very consistent with the distribution paramedic service type in the target population, which indicates 50.94% to 58.5% of paramedic students describe themselves as non–fire-based paramedics.

The sample included 4570 (77%) male students and 1396 (23%) female students, which is similar to the distribution of gender in the target population. With respect to gender distribution within service type, it should be noted there were 259 (10.2%) females reporting fire as service type, 1137 (33.3%) reported non-fire as service type. When compared to the target population, females are over represented in the sample with respect to distribution by service type. Of the 743 VPE users, 571 (77%) indicated gender as male and 172 (23%) indicated gender as female. In addition, the sample included 5223 non-VPE users, 3999 (77%) who indicated gender as male and 1224 (23%) who indicated gender as female. This distribution of gender by VPE usage is very consistent with the distribution paramedic gender in the target population, which indicates 76.29% to 77.43% of paramedic students describe their gender as male.

3.5 Study Intervention

The intervention in this research was the use of a computer-based clinical simulation program to supplement the content of the paramedic education program. The
computer-based clinical simulation program used in this study was Virtual Patient
Encounters (VPE), developed by Elsevier, Inc., to supplement the comprehensive
Mosby’s Paramedic Textbook. VPE is a computer-based interactive clinical simulation
product delivered using a computer, computer screen, speakers, mouse, and printer. It
includes 15 multimedia–enriched, interactive clinical simulations that are accompanied
by a corresponding student study guide and course textbook. Each simulation begins
with a video of an actual patient encounter. After viewing the video, students are
directed to complete various assignments and exercises included in the student study
guide that are related to preparatory topics, such as scene assessment and management,
and initial patient assessment. As the paramedic course progresses and patient
management topics are introduced, the students are directed back to the software to select
patient presentations that allow students to interact with a simulated patient and
environment, to conduct continued patient assessments, gather additional information,
and make decisions about appropriate management of the patient. According to Tashiro
(2006), clinical simulation programs such as VPE, aid students in developing decision-
making skills and clinical judgment through realistic or practical applications in
nonclinical educational settings.

3.6 Study Instrumentation

Data collections used for this research included two examinations developed and
administered by the NREMT: The EMT national credentialing examination and the
paramedic national credentialing examination.

According to the NREMT (2006b), using a random sample of 2000 paramedic
students, the overall pass rate for the time period January 1, 2006 through December 31, 2006 was 65.6%. This is comparable to the 65.1% rate for the previous 12-month period (January 1, 2005 through December 31, 2005). The standard error of the mean (SEM) on the paramedic examination was 0.18.

Each test taker was allowed a time limit of 2.5 hours to complete the computer-adaptive examination. The mean test time was approximately 90 minutes (1.5 hours) and the longest test time was approximately 150 minutes (2.5 hours). Ninety-nine percent (99%) of the test takers finished in 144 minutes or less.

Mean and median item difficulties were .06 and .11 logits respectively. The range of item difficulty was -2.95 to 2.98. Mean and median point biserial correlations were .21 and .20 respectively. Minimum point biserial was .02. Maximum infit mean square was 1.04 and the maximum outfit mean square was 1.09.

Reliability was estimated for the total test and content area scores, based on the standard deviation of test scores (or content area scores) and the mean SEM as follows:

\[
\hat{r} = 1 - \frac{SEM^2}{SD^2}
\]  

Equation 2: Total Test and Content Area Reliability

As shown in Table 5, the total test has good estimated reliability (.89), whereas the content areas have relatively poor estimated reliability (.45 to .66).
<table>
<thead>
<tr>
<th>Total &amp; Breathing</th>
<th>Airway</th>
<th>Cardiology</th>
<th>Trauma</th>
<th>Medical</th>
<th>Obstetrics &amp; Pediatrics</th>
<th>EMS Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SEM</td>
<td>0.18</td>
<td>0.44</td>
<td>0.50</td>
<td>0.45</td>
<td>0.48</td>
<td>0.47</td>
</tr>
<tr>
<td>SD of Scores</td>
<td>0.56</td>
<td>0.74</td>
<td>0.75</td>
<td>0.78</td>
<td>0.64</td>
<td>0.75</td>
</tr>
<tr>
<td>Estimated Reliability</td>
<td>0.89</td>
<td>0.64</td>
<td>0.57</td>
<td>0.66</td>
<td>0.45</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 5: Estimated Reliability of Total Score and Content Area Scores

According to the NREMT (2006b), the overall pass rate on the EMT examination for the time period January 1, 1977 through June 30, 2007 was 70.18%. Using a random sample of 2000 EMT students, the standard error of the mean (SEM) on the EMT examination was 4.794 over the examination period. Each test taker was allowed a time limit of 2.5 hours to complete the pen and paper examination. Mean item difficulties for the examination were 0.725. The range of item difficulty was 0.35 to 0.98. Mean point biserial correlations was 0.269. Total test reliability was 0.91 (National Registry of Emergency Medical Technicians, 2006b).

In addition, validity of the examinations was determined using construct and content methods. The NREMT establishes construct validity by ensuring each examination was developed to reflect the depth and breadth identified in the National EMS Practice Analysis (NREMT, 2006b). The NREMT establishes content validity by ensuring items included within its examinations were referenced to the national standard curricula, as well as the paramedic textbooks commonly used by educational institutions.
3.7 Data Analysis

The manager of information technology for the NREMT, acted as the “honest broker” for retrieval of study participant data from the NREMT database. The EMS executive editor at Elsevier, acted as “honest broker” for identifying programs using VPE during the study period and providing the de-identified final summary report from the focus group interview. The researcher combined the two sets of quantitative data. Prior to data analysis, accuracy of data entry and missing data were examined to determine the randomness of the missing data, using visual analysis of the missing data’s sampling distribution, Levene’s test for equality of variance between missing and obtained data, and an independent t-test of differences in mean dependent scores between missing and obtained data were conducted.

Data analysis for all seven questions included descriptive statistics and the results of the ANCOVA. For the dependent variable and the covariate, descriptive statistics including mean, standard deviations, minimum and maximum values, kurtosis and skewness were reported. These descriptive statistics provide valuable information about the group of students formed by the independent variables.

SPSS 14.0 was used to analyze the study data, using a three-way ANCOVA with an overall alpha level of 0.05. The $F$ statistic was evaluated to determine the presence of a three-way interaction, any two-way interactions, and all main effects. If the $F$ statistic associated with an interaction or a main effect was significant, the null hypothesis was rejected. If any higher order effects were discovered, the lower order effects were interpreted in the context of the higher order interactions (Keppel and Wickens, 2004).

Analysis of the ANCOVA results started with the interactions and proceeded to
the main effects. Plots of any significant interaction and main effect were provided to aid in visual interpretation of the magnitude of the effects. Because each group associated with main effects in this study include only 2 levels, post hoc comparisons were not conducted.

Effect sizes for this study were reported as partial eta squared (partial $\eta^2$). Partial eta squared can be defined as the ratio of variance accounted for by an effect and that effect plus its associated error variance. Keppel and Wickens (2004) state that small effect captures about 1% of the variance, a medium effect captures about 6% of the variance, and a large effect captures at least 15% of the variance. These effect benchmarks were used to evaluate the partial $\eta^2$ measures in this study.

To ensure use of the ANCOVA was appropriate and that results of the analysis were interpreted unambiguously, the following assumptions were evaluated: independence, normality, and homogeneity of variance, homogeneity of regression slopes, and linearity of covariate and dependent variables.

The assumption of independence requires that the observations are independent. For this study, the examination score achieved by one individual must not influence another individual’s examination score. Conversely, an individual’s examination score must not be affected by the examination scores of the other individuals included in the study. Due to the convenience sampling and the nonequivalent control group design, students are nested within paramedic classes, and paramedic classes are nested within accredited paramedic education programs. This presents a threat to the independence assumption because paramedic faculty may utilize patient presentations common to their location, particularly when program locations differ by population centers, (i.e., urban
population centers versus rural population centers). This is unlikely, however, as each accredited paramedic program is required to use a nationally standardized curriculum that specifies student competencies in terms of clearly defined patient care procedures in equally defined patient presentations. The requirement for a nationally standardized curriculum controlled for this threat to the assumption of independence. In addition, the measurement of student scores on the national EMT credentialing examination and the national paramedic credentialing examination were conducted individually at secure testing centers, that were independent of the demographics of the student population, patient population, location of the education program, location of the testing center, and date/time of the measurement.

The assumption of normality suggests that each dependent variable is normally distributed (Hair, Anderson, Tatham and Black, 1998). A Q-Q plot of the dependent variable and covariate were conducted to assess for univariate normality. Observations for the dependent variable and the covariate were ordered in increasing magnitude by the independent variable and then plotted against their expected normal quantiles. Plots representing a straight line, or nearly a straight line, suggest the assumption of univariate normality is reasonable. A histogram of the paramedic score distribution for each independent variable was plotted as an additional visual evaluation of normality.

Based on the central limit theorem, the distribution of the national paramedic credentialing examination scores are assumed to be distributed normally. While a convenience sample was used for this study, the paramedic examination scores represent a full year of student scores (n=5966) drawn from the target population and according to the central limit theorem (Keppel and Wickens, 2004), the distribution of sample means
taken from a large population approaches a normal curve. The central limit theorem does not hold for the student scores on the national EMT credentialing examination because the research design only allows students who achieved a passing score of 70 or greater to be included in the sample. This effectively attenuates the lower limit of the sample scoring distribution toward the mean of the original scoring distribution and results in a positive skew in the distribution. Even with this assumed violation of univariate normality, it should be noted that ANCOVA is robust with respect to departures from normality. As pointed out by Stevens (2006) and Hair et al. (1998), departures from normality generally result in only slight effects on Type I error rates in ANCOVA.

The assumption of homogeneity of variance requires that the variance of each group within the study be equivalent. If sampling resulted in approximately equivalent group sizes, the impact of violation of this assumption is minimal. If the ratio of difference in size between the largest group and the small group is greater than 1.5, the “researcher should test and correct for unequal variances” (Hair, 1998, p. 348). Box’s M is typically used to test for the assumption of homogeneity of variance-covariance matrices. Box's M is extremely sensitive to violations of the assumption of normality. For this reason, it is recommended to test at the p=.001 level, especially when sample sizes are unequal (Meyers, Gamst, and Guarino, 2006).

While these assumptions are foundational to the use of ANCOVA, Hair et al. (1998) also suggest that it is important to assess the linearity and multicollinearity of the dependent variables and covariates. In this study, linearity was assessed by examining scatter plots of the variables to identify any nonlinear relationships patterns. Additionally, linearity was assessed by running a regression analysis and comparing
regression slopes of the dependent variable and covariate within each independent variable. Multicollinearity was evaluated by assessing the tolerance and the variance of inflation factor (VIF). Tolerance of a variable is the coefficient of determination for the prediction of that variable by the other predictor variables. Tolerance values approaching zero indicate high collinearity. The VIF measures the effect of other predictor variables on a regression coefficient and expresses the degree to which collinearity among the predictors degrades the precision of an estimate. Typically a VIF value greater than 10 is of concern.

3.8 Research Questions

3.8.1 Research Question One

The first research question investigated in this study was, “Does the inclusion of computer-based clinical simulations within the paramedic education program have a positive effect on student performance on the national paramedic credentialing examination?”

3.8.1.1 Null and Alternative Hypotheses

The null hypothesis for research question one was, “after controlling for scores attained on the EMT examination, there will be no significant differences in the mean examination scores on the paramedic examination between students completing traditional paramedic education programs and students supplementing traditional paramedic education programs with Virtual Patient Encounters.”

\[ H_0: \mu_{a1} = \mu_{a2} \]

where:
\( \mu_{a1} = \) mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.

\( \mu_{a2} = \) mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.

The alternative hypothesis for research question one was, “after controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination for students using computer-based clinical simulations will be higher than the scores achieved by students who did not use computer-based clinical simulations.”

\( H_1: \mu_{a1} > \mu_{a2} \) where:

\( \mu_{a1} = \) mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.

\( \mu_{a2} = \) mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.

3.8.1.2 Research Design

For research question one, the independent variable was usage/non-usage of computer-based clinical simulation software (Elsevier’s Virtual Patient Encounters) within the traditional paramedic education program. The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this
research question. The causal comparative design for research question one is presented below:

<table>
<thead>
<tr>
<th>VPE Usage</th>
<th>O₁</th>
<th>X₁</th>
<th>X₂</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>No VPE Usage</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
</tbody>
</table>

Table 6: Question One Research Design

Where: $X_1 =$ Traditional paramedic program, $X_2 =$ Computer-based clinical simulations, $O_1 =$ EMT examination, and $O_2 =$ Paramedic examination.

3.8.2 Research Question Two

The second research question investigated in this study was, “Does affiliation with the fire service have an effect on student performance on the national paramedic credentialing examination when compared to nonaffiliation with the fire service?”

3.8.2.1 The Null and Alternative Hypothesis

The null hypothesis for research question two was, “after controlling for scores attained on the EMT examination, there will be no significant differences in the mean examination scores on the paramedic examination between students affiliated with fire-based paramedic services and those affiliated with non–fire-based paramedic services.

$H_0: \mu_{b1} = \mu_{b2}$ where:

$\mu_{b1} =$ mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.
μb2 = mean examination scores on the paramedic examination achieved by
students affiliated with non–fire-based paramedic services.

The alternative hypothesis for research question two was, “after controlling for
scores attained on the EMT examination, the mean examination scores on the paramedic
examination achieved by students affiliated with fire-based paramedic services will be
higher than scores achieved by student affiliated with non–fire-based paramedic
services.”

H0: μb1 > μb2 where:

μb1 = mean examination scores on the paramedic examination achieved by
students affiliated with fire-based paramedic services.

μb2 = mean examination scores on the paramedic examination achieved by
students affiliated with non–fire-based paramedic services.

3.8.2.2 Research Design

For research question two, the independent variable was the service type (fire-
based/ non–fire-based). The dependent variable was the student score on the paramedic
examination, while the covariate was the student score on the EMT examination. A
general nonequivalent control group design, using a pretest (covariate)/posttest
comparison (Campbell and Stanley, 1966), was adopted for this research question. The
causal comparative design for research question two is presented below:
<table>
<thead>
<tr>
<th>Fire-Based</th>
<th>O₁</th>
<th>X</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non–Fire-Based</td>
<td>O₁</td>
<td>X</td>
<td>O₂</td>
</tr>
</tbody>
</table>

Table 7: Question Two Research Design

Where, X = Traditional paramedic program and traditional paramedic program supplemented with computer-based clinical simulations, O₁ = EMT examination, and O₂ = Paramedic examination.

3.8.3 Research Question Three

The third research question investigated in this study was, “Does gender have an effect on student performance on the national paramedic credentialing examination?”

3.8.3.1 The Null and Alternative Hypothesis

The null hypothesis for research question three was, “after controlling for scores attained on the EMT examination, there will be no significant differences in the mean examination scores on the national paramedic examination between male and female students.”

\[ H_0: \mu_{e1} = \mu_{e2} \]

where:

\[ \mu_{e1} = \text{mean examination scores on the paramedic examination achieved by male students.} \]

\[ \mu_{e2} = \text{mean examination scores on the paramedic examination achieved by female students.} \]

The alternative hypothesis for research question three was, “after controlling for
scores attained on the NREMT EMT examination, the mean examination scores on the paramedic examination achieved by male students will be higher than scores achieved by female students."

\[ H_0: \mu_{c1} > \mu_{c2} \]

where:

\[ \mu_{c1} = \text{mean examination scores on the paramedic examination achieved by male students.} \]

\[ \mu_{c2} = \text{mean examination scores on the paramedic examination achieved by female students.} \]

3.8.3.2 Research Design

For research question three, the independent variable was gender (male/female). The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this research question. The causal comparative design for research question three is presented below:

<table>
<thead>
<tr>
<th>Male</th>
<th>( O_1 )</th>
<th>( X )</th>
<th>( O_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>( O_1 )</td>
<td>( X )</td>
<td>( O_2 )</td>
</tr>
</tbody>
</table>

Table 8: Question Three Research Design

Where \( X = \) Traditional paramedic program and traditional paramedic program supplemented with computer-based clinical simulations, \( O_1 = \) EMT examination, and
3.8.4 Research Question Four

The fourth research question investigated in this study was, “Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and service type on student performance on the national paramedic credentialing examination?”

3.8.4.1 The Null and Alternative Hypothesis

The null hypothesis for research question four was, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by service type will not differ across levels of computer-based clinical simulation usage.”

\[ H_0: (\mu_{b1} \times \mu_{a1}) = (\mu_{b2} \times \mu_{a1}) = (\mu_{b1} \times \mu_{a2}) = (\mu_{b2} \times \mu_{a2}) \]

where:

\[ \mu_{a1} = \text{mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.} \]

\[ \mu_{a2} = \text{mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.} \]

\[ \mu_{b1} = \text{mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.} \]

\[ \mu_{b2} = \text{mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.} \]
The alternative hypothesis for research question four was, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by service type will differ across levels of computer-based clinical simulation usage.”

\[ H_0: (\mu_{b1} \cdot \mu_{a1}) \neq (\mu_{b2} \cdot \mu_{a1}) \neq (\mu_{b1} \cdot \mu_{a2}) \neq (\mu_{b2} \cdot \mu_{a2}) \]

where:

\( \mu_{a1} = \) mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.

\( \mu_{a2} = \) mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.

\( \mu_{b1} = \) mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.

\( \mu_{b2} = \) mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.

3.8.4.2 Research Design

For research question four, the independent variables were usage/non-usage of computer-based clinical simulation software (Elsevier’s Virtual Patient Encounters) within the traditional paramedic education program and service type (fire-based/non–fire-based). The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this research question. The causal
comparative design for research question four is presented below:

<table>
<thead>
<tr>
<th></th>
<th>O₁</th>
<th>X₁</th>
<th>X₂</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-Based</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
<tr>
<td>Non–Fire-Based</td>
<td>O₁</td>
<td></td>
<td>X₂</td>
<td>O₂</td>
</tr>
<tr>
<td>Non–Fire-Based</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
</tbody>
</table>

Table 9: Question Four Research Design

Where X₁ = Traditional paramedic program, X₂ = Computer-based clinical, simulations, O₁ = EMT examination, and O₂ = Paramedic examination.

3.8.5 Research Question Five

The fifth research question investigated in this study was, “Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and gender on student performance on the national paramedic credentialing examination?”

3.8.5.1 The Null and Alternative Hypothesis

The null hypothesis for research question five was, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by gender will not differ across levels of computer-based clinical simulation usage”.

\[ H_0: (\mu_{c1} \times \mu_{a1}) = (\mu_{c2} \times \mu_{a1}) = (\mu_{c1} \times \mu_{a2}) = (\mu_{c2} \times \mu_{a2}) \] where:

\[ \mu_{a1} = \text{mean examination scores on the paramedic examination achieved by} \]
students supplementing traditional paramedic education programs with Virtual Patient Encounters.

\[ \mu_{a2} = \text{mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.} \]

\[ \mu_{c1} = \text{mean examination scores on the paramedic examination achieved by male students.} \]

\[ \mu_{c2} = \text{mean examination scores on the paramedic examination achieved by female students.} \]

The alternative hypothesis for research question five was, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by gender will differ across levels of computer-based clinical simulation usage.”

\[ H_0: (\mu_{c1} * \mu_{a1}) \neq (\mu_{c2} * \mu_{a1}) \neq (\mu_{c1} * \mu_{a2}) \neq (\mu_{c2} * \mu_{a2}) \]

where:

\[ \mu_{a1} = \text{mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.} \]

\[ \mu_{a2} = \text{mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.} \]

\[ \mu_{c1} = \text{mean examination scores on the paramedic examination achieved by male students.} \]

\[ \mu_{c2} = \text{mean examination scores on the paramedic examination achieved by female students.} \]
3.8.5.2 Research Design

For research question five, the independent variables were usage/non-usage of computer-based clinical simulation software (Elsevier’s Virtual Patient Encounters) within the traditional paramedic education program and gender (male/female). The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this research question. The causal comparative design for research question five is presented below:

<table>
<thead>
<tr>
<th></th>
<th>O₁</th>
<th>X₁</th>
<th>X₂</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
<tr>
<td>Female</td>
<td>O₁</td>
<td>X₁</td>
<td>X₂</td>
<td>O₂</td>
</tr>
<tr>
<td>Female</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
</tbody>
</table>

Table 10: Question Five Research Design

Where $X₁ =$ Traditional paramedic program, $X₂ =$ Computer-based clinical simulations, $O₁ =$ EMT examination, and $O₂ =$ Paramedic examination.

3.8.6 Research Question Six

The sixth research question investigated in this study was, “Is there an interaction effect of inclusion of service type and gender on student performance on the national paramedic credentialing examination?”
3.8.6.1 The Null and Alternative Hypothesis

The null hypothesis for research question six, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by service type will not differ across levels of gender.”

\[ H_0: (\mu_{b1} \times \mu_{c1}) = (\mu_{b2} \times \mu_{c1}) = (\mu_{b1} \times \mu_{c2}) = (\mu_{b2} \times \mu_{c2}) \]

where:

\( \mu_{b1} \) = mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.

\( \mu_{b2} \) = mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.

\( \mu_{c1} \) = mean examination scores on the paramedic examination achieved by male students.

\( \mu_{c2} \) = mean examination scores on the paramedic examination achieved by female students.

The alternative hypothesis for research question six, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved by service type will differ across levels of gender.”

\[ H_0': (\mu_{b1} \times \mu_{c1}) \neq (\mu_{b2} \times \mu_{c1}) \neq (\mu_{b1} \times \mu_{c2}) \neq (\mu_{b2} \times \mu_{c2}) \]

where:

\( \mu_{b1} \) = mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.

\( \mu_{b2} \) = mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.

\( \mu_{c1} \) = mean examination scores on the paramedic examination achieved by male students.
\[ \mu_{e2} = \text{mean examination scores on the paramedic examination achieved by female students.} \]

3.8.6.2 Research Design

For research question six, the independent variables were service type (fire-based/non–fire-based) and gender (male/female). The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this research question. The causal comparative design for research question six is presented below:

<table>
<thead>
<tr>
<th></th>
<th>( O_1 )</th>
<th>( X )</th>
<th>( O_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-Based/Male</td>
<td>( O_1 )</td>
<td>( X )</td>
<td>( O_2 )</td>
</tr>
<tr>
<td>Fire-Based/Female</td>
<td>( O_1 )</td>
<td>( X )</td>
<td>( O_2 )</td>
</tr>
<tr>
<td>Non–Fire-Based/Male</td>
<td>( O_1 )</td>
<td>( X )</td>
<td>( O_2 )</td>
</tr>
<tr>
<td>Non–Fire-Based/Female</td>
<td>( O_1 )</td>
<td>( X )</td>
<td>( O_2 )</td>
</tr>
</tbody>
</table>

Table 11: Question Six Research Design

Where \( X = \) Traditional paramedic program and traditional paramedic program supplemented with computer-based clinical simulations, \( O_1 = \) EMT examination, and \( O_2 = \) Paramedic examination.

3.8.7 Research Question Seven

The seventh research question investigated in this study was, “Is there an
interaction effect of inclusion of computer-based clinical simulations within the paramedic education program, service type, and gender on student performance on the national paramedic credentialing examination?"

3.8.7.1 The Null and Alternative Hypothesis

The null hypothesis for research question seven was, “After controlling for scores attained on the national EMT credentialing examination, the mean examination scores on the national paramedic credentialing examination achieved across levels of computer-based simulation usage will not differ across levels of service type and gender.”

\[
H_0: (\mu_{a1} \ast \mu_{b1} \ast \mu_{c1}) = (\mu_{a1} \ast \mu_{b1} \ast \mu_{c2}) = (\mu_{A1} \ast \mu_{b2} \ast \mu_{c1}) = (\mu_{A1} \ast \mu_{b2} \ast \mu_{c2}) = (\mu_{a2} \ast \mu_{b1} \ast \mu_{c1}) = (\mu_{a2} \ast \mu_{b1} \ast \mu_{c2}) = (\mu_{a2} \ast \mu_{b2} \ast \mu_{c1}) = (\mu_{a2} \ast \mu_{b2} \ast \mu_{c2})
\]

where:

\[
\mu_{a1} = \text{mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.}
\]

\[
\mu_{a2} = \text{mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.}
\]

\[
\mu_{b1} = \text{mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.}
\]

\[
\mu_{b2} = \text{mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.}
\]

\[
\mu_{c1} = \text{mean examination scores on the paramedic examination achieved by male students.}
\]
\( \mu_{c2} = \) mean examination scores on the paramedic examination achieved by female students.

The alternative hypothesis for research question seven was, “After controlling for scores attained on the EMT examination, the mean examination scores on the paramedic examination achieved across levels of computer-based simulation usage will differ across levels of service type and gender.”

\[
H_0: (\mu_{a1} \times \mu_{b1} \times \mu_{c1}) \neq (\mu_{a1} \times \mu_{b1} \times \mu_{c2}) \neq (\mu_{A1} \times \mu_{b2} \times \mu_{c1}) \neq (\mu_{A1} \times \mu_{b2} \times \mu_{c2}) \neq (\mu_{a2} \times \mu_{b1} \times \mu_{c1}) \neq (\mu_{a2} \times \mu_{b1} \times \mu_{c2}) \neq (\mu_{a2} \times \mu_{b2} \times \mu_{c1}) \neq (\mu_{a2} \times \mu_{b2} \times \mu_{c2}) \]

where:

\( \mu_{a1} = \) mean examination scores on the paramedic examination achieved by students supplementing traditional paramedic education programs with Virtual Patient Encounters.

\( \mu_{a2} = \) mean examination scores on the paramedic examination achieved by students completing traditional paramedic education programs.

\( \mu_{b1} = \) mean examination scores on the paramedic examination achieved by students affiliated with fire-based paramedic services.

\( \mu_{b2} = \) mean examination scores on the paramedic examination achieved by students affiliated with non–fire-based paramedic services.

\( \mu_{c1} = \) mean examination scores on the paramedic examination achieved by male students.

\( \mu_{c2} = \) mean examination scores on the paramedic examination achieved by female students.
3.8.7.2 Research Design

For research question seven, the independent variables were usage/non-usage of computer-based clinical simulation software (Elsevier’s Virtual Patient Encounters) within the traditional paramedic education program, service type (fire-based/non–fire-based) and gender (male/female). The dependent variable was student score on the paramedic examination while the covariate was student score on the EMT examination.

A general nonequivalent control group design, using a pretest (covariate)/posttest comparison (Campbell and Stanley, 1966), was adopted for this research question. The causal comparative design for research question seven is presented below:

<table>
<thead>
<tr>
<th>Male/Fire-Based</th>
<th>O₁</th>
<th>X₁</th>
<th>X₂</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/Non–Fire-Based</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
<tr>
<td>Female/Fire-Based</td>
<td>O₁</td>
<td>X₁</td>
<td>X₂</td>
<td>O₂</td>
</tr>
<tr>
<td>Female/Non–Fire-Based</td>
<td>O₁</td>
<td>X₁</td>
<td></td>
<td>O₂</td>
</tr>
</tbody>
</table>

Table 12: Question Seven Research Design

Where X₁ = Traditional paramedic program, X₂ = Computer-based clinical simulations, O₁ = EMT examination, and O₂ = Paramedic examination.

3.8 Internal and External Validity

Threats to validity include selection and interaction effects. The causal comparative design did not permit random sampling because assignment to the experimental group or the control group was preexisting based on the program director’s choice to use Virtual Patient Encounters. The interaction effect is related to the students’
knowledge and skills as an EMT prior to entering the paramedic education program.

Prior research indicates that there is a significant correlation (0.38) between an individual’s performance on the EMT examination and subsequent performance on the paramedic examination (Fernandez and Studneck, 2009). This threat to validity was controlled for statistically by using the EMT examination score as a covariate in the study design.

3.9 Assumptions

The following assumptions were made to justify the appropriateness of the data used to answer the questions of this research:

1. The education program faculty and students in the experimental group used Elsevier’s Virtual Patient Encounters in accordance to the directions provided in the implementation manual.

2. No student was included in the sample by virtue of completing an advanced nursing or medical education program in lieu of the traditional paramedic education program.

3. The paramedic examination is a valid measure of an individual’s ability to apply decision-making skills and clinical judgment to the range of possible patient presentations in the operational out-of-hospital environment.

3.10 Sampling Limitations

The major limitations of the research are as follows:

1. The use of a convenience sample and a nonequivalent group design present
some limitations to the study. This research investigated students completing paramedic programs and attempting the paramedic examination. The selection of students was not random. Assignment of students to the various groups within the research design was preexisting, based on the paramedic faculty’s choice to use the Virtual Patient Encounters product, as well as the distribution of gender and service type within the convenience sample. The results of the study should not be generalized without considering this sampling limitation.

2. The sample distribution of gender for assessing the main effects in the research design is similar to the distribution of gender in the target population. However, when assessing gender interactions with respect to service type, females are overrepresented in the sampling distribution. The results of the study related to the main effects of gender are generalizable to the paramedic testing population. However, the results related to interactions of gender and service type may not be generalizable to the paramedic population.

3. EMT examination scores were collected over a 30-year period between 1977 and 2007. The EMT examinations most certainly varied in content over the 30-year period, based on changes in practice and advances in medical care and equipment. In addition, educational practices and pedagogies within EMT education have advanced over the same period. While the passing standard has remained consistent over the data collecting period, the variance in EMT examination scores associated with changes in examination content and educational practices has not been determined. The results of this study should not be generalized without considering the impact of these unexplained variances.
4. In order to ensure protection of the student, the use of the Virtual Patient Encounters product was provided in a de-identified data set. This resulted in knowing that a student used the product but did not provide a method of determining the manner in which the product was used by the student within the education program. Therefore, the study was not designed to ensure that faculty and students used the Virtual Patient Encounters product in a consistent manner, as prescribed in the implementation manual. The results of the study, while reflecting use of the VPE product, are generalizable only to the use of the product, not necessarily to the prescribed method of use.

5. Perhaps the most important consideration when considering appropriate sample size to use with the ANCOVA is to ensure representativeness of the sample (Huberty and Petoskey, 2000). These researchers suggest ensuring each factorial cell contains a minimum of 10 times the number of outcome variables. The current study contains 1 outcome variables and would require a minimum of 10 students in each cell. However, if the effect size is small, this sample size may not possess sufficient power to detect a difference, if it exists, thus increasing the possibility of committing a Type II error. Hair, Anderson, Tatham and Black (1998, p. 352) suggest “group sizes of fewer than 50 members” may be problematic when trying to achieve sufficient power. The smallest factorial cell size in the current study contains 29 students (VPE by fire service by female) and may not contain sufficient power to detect an interaction effect, if one exists. This is a limitation of the convenience sampling used for this study and must be considered when interpreting the results of the ANCOVA.
3.11 Focus Group

In addition to the quantitative analysis, an end-user focus group was conducted jointly by the Elsevier editorial and marketing staff to investigate how the VPE product was used within the paramedic education environment and to elicit information relative to improving the product in subsequent updates. With respect to this study, review of the focus group interview results focused on the following questions:

1. Did faculty use the VPE product as described in the implementation manual?
2. How was the VPE product integrated across the paramedic curriculum?
3. How did faculty use the concept of scaffolding to incorporate the VPE product into the paramedic educational experience?
4. What debriefing and remediation techniques were used following the students’ experience with the VPE product?
5. Did the VPE product improve students’ decision-making and critical-judgment abilities?

3.11.1 Research Design

Members of the Elsevier marketing staff were responsible for developing the focus group interview questions, which were then reviewed and revised by the entire research team to ensure the purpose and specific goals were congruent with the interview questions. The intent of the questions was to allow end users of the VPE product to voice their thoughts about, feelings toward, and experiences with the computer-based clinical simulation product. The final set of focus group interview questions included:

1. What was the primary reason you or your school chose to use the VPE product?
2. How many classes/cohorts within your paramedic program have used the VPE product?

3. What were the issues and barriers to implementation of the VPE product within your paramedic program?

4. How useful were the VPE study guide, software, implementation manual, and student textbook in supporting the students’ use of the VPE product?

5. What were the greatest benefits of the use of the VPE product within your paramedic program?

6. If you could make any change to the VPE product, what would you change?

Focus group interviews were conducted in conjunction with an Elsevier EMS Advisory Board meeting. The focus group interviews were conducted by a member of the editorial staff trained in the specific protocols for conducting interviews and leading the discussions of the focus group participants. The interviews were not tape recorded, so that the participants would feel more relaxed and less intimated. Two members of the marketing staff and one member of the editorial staff were responsible for recording observations and responses of the focus group interviews.

3.11.2 Focus Group Membership

Keeping the stated purpose of the focus group in mind, investigating how the VPE product was used within the paramedic education environment and eliciting information relative to the improvement of the software in subsequent product updates, the research team attempted to achieve representativeness of current paramedic education program
demographics. The sampling approach was chosen to find central tendencies that could be further investigated through subsequent focus groups and marketing surveys.

The initial selection criterion was restricted to paramedic programs that purchased the VPE product during the inclusive months of January 1, 2007 and December 31, 2007. From the list of programs purchasing the VPE product during the inclusive dates, 12 paramedic programs were invited to participate in the focus group interviews, based on the following additional selection criteria:

1. The program must have conducted at least one entry-level paramedic program using the VPE product during the inclusive dates of January 1, 2007 and December 31, 2007.

2. The overall focus group sample must have closely paralleled the national distribution of paramedic program environments with respect to academic facility (i.e., university, community college, fire service, EMS academy).

3. Focus group participants must have been the primary faculty responsible for the implementation and use of the VPE product within the paramedic education program.

3.11.3 Data Analysis

Data analysis was conducted at five levels. During level one, the three observers/recorders present during the focus group interviews completed summary reports of his or her observations. These reports were copied and provided to each member of the research team. Level two included analysis of the observer/recorder summary reports by select members of the research team to identify trends and relevant
issues filtered by each specific interview question. Each research team member developed a summary analysis that was then forwarded to the EMS editor who complete level three of the analysis by reviewing the summary analyses and developing a final summary report. Level four of the analysis was completed by sending the final summary report to all members of the research team for review, revision, and completion of the final report for publication. The fifth and final level of the analysis consisted of sending the final report to the focus group participants for member checking. For the purpose of this study, the final report will be reviewed and analyzed to determine if there were trends in how the VPE product was used with respect to coaching, scaffolding, debriefing, and remediation.

3.12 Ethics Review and IRB Approval

Ethics review and IRB approval was requested through The Ohio State Institutional Review Board and the researchers were informed that no approval was necessary for this research, based on the retrospective analysis of existing data. Permission to utilize pre-existing, de-identified data was obtained from the National Registry of Emergency Medical Technicians and Elsevier Inc. No additional data were collected.

3.13 Summary

This chapter outlined the overall qualitative causal comparative research design, the design for the evaluation of each research question, and the data analysis procedures used in this study. The target population for this study was graduates of paramedic
education programs that completed the NREMT paramedic examination between the inclusive dates of July 1, 2007 and June 30, 2008. A convenience sample obtained from the NREMT of all paramedic examinations administered during the inclusive time frame was used to evaluate the research questions. The intervention was the use/non-use of computer-based clinical simulations within the traditional paramedic education program. A pretest/posttest design was used and initial group differences in test scores was controlled by using the EMT score as a covariate. In addition to score differences related to use of computer-based clinical simulations, service type and gender were included in the factorial design. An end-user focus group was included in the study design to determine how faculty utilized the computer-based clinical simulation product within the paramedic program. Findings of the data analysis are reported and discussed in Chapter 4.
Chapter 4: Results and Discussion

The present research consists of a causal-comparative study using a nonequivalent control group design that was conducted to answer the following questions:

1. Does the inclusion of computer-based clinical simulations within the paramedic education program have a positive effect on student performance on the paramedic examination?

2. Does affiliation with the fire service have an effect on student performance on the paramedic examination when compared to nonaffiliation with the fire service?

3. Does gender have an effect on student performance on the paramedic examination?

4. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and service type on student performance on the paramedic examination?

5. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program and gender on student performance on the paramedic examination?

6. Is there an interaction effect of service type and gender on student performance on the paramedic examination?

7. Is there an interaction effect of inclusion of computer-based clinical simulations within the paramedic education program, service type, and gender on student
performance on the paramedic examination?

The research was accomplished using an ANCOVA factorial design where paramedic examination scores represented the outcome variable and EMT examination scores served as the covariate. Independent variables included VPE usage, EMS service type, and student gender.

A sample of 5966 students completing a state-approved paramedic education program and completing their first attempt of the paramedic examination between the inclusive dates of July 1, 2007 and June 30, 2008 were used in the research. Using demographic data supplied by the National Registry of Emergency Medical Technicians (NREMT), the sample of students was grouped based on the following categorical variables: Use of Virtual Patient Encounters (use/non-use), service type (fire-based/non–fire-based), and gender (male/female). The student’s score achieved on the EMT examination served as the covariate for the statistical analysis. Qualitative analysis of data obtained from focus and end-user groups conducted by the Elsevier executive editor of emergency medical services was used to determine the method in which the computer-based clinical simulation product was utilized within the paramedic education programs included in this sample. This chapter includes evidence of reliability and validity of the study instrumentation, descriptive statistics, results of the analysis of missing data, results of the ANCOVA assumptions, results of the ANCOVA analysis, and outcomes of the end-user focus group interviews.

4.1 Reliability and Validity of the National Credentialing Examinations

The NREMT develops both the paramedic and EMT national credentialing
examinations following the item development process described by Morris and Free (2001) and general test development guidelines included in the Standards and Guidelines for Educational and Psychological Testing (AERA, APA, and NCME, 1999). In addition, the NREMT submits to external review of its tests and testing programs by the National Commission for Certifying Agencies (NCCA), which is the accreditation arm of the National Organization for Competency Assurance (NOCA). NCCA accreditation means that the standards set for examination development, administration, scoring, and standard setting used by the NREMT have been reviewed by the NCCA and deemed credible for ensuring the health, welfare, and safety of the public.

The reliability statistic (Chronbach’s alpha) and mean item discrimination (mean item point biserial) for the paramedic and EMT examinations are presented in Table 13.

<table>
<thead>
<tr>
<th>Test</th>
<th>Number in Sample</th>
<th>Minimum Items</th>
<th>Maximum Items</th>
<th>Reliability</th>
<th>Mean Item Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMT</td>
<td>5966</td>
<td>150</td>
<td>150</td>
<td>0.90</td>
<td>0.17</td>
</tr>
<tr>
<td>Paramedic</td>
<td>5966</td>
<td>80</td>
<td>150</td>
<td>0.91</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Table 13: Reliability/Discrimination Indices for National Credentialing Examinations

The reliability coefficients of the paramedic and EMT examinations are high (0.91 and 0.90 respectively) for the sample included in the study. The high reliability of the examinations suggests high internal consistency of items and provides evidence of unidimensionality of the measurement. A problem related to the measure of reliability of the examination items and overall student scores occurs when the range of the scores is
restricted by distribution of item difficulties. (Cohen, Cohen, West, and Aiken, 2003). A floor effect can occur when the majority of items on an examination are extremely difficult for the population of interest and results in large number of test takers receiving scores near the lower end of the scoring scale. The range of item difficulties for the sample of all individuals attempting the EMT examination during the inclusive dates of the study was 0.35-0.98 while the range of item difficulties for the convenience sample was 0.35-0.99. Thus, the floor effect in the current study does not appear to be a result of the distribution of item difficulties.

It is important to remember the inclusion of the EMT examination as a covariate in this study was to control for the amount of variance shared by both the EMT and paramedic examinations, not to predict paramedic student success based on national EMT credentialing scores. If prediction of paramedic examination scores from EMT examination scores were the focus of the study, truncating the EMT examination scores would attenuate the outcomes and significantly underestimate the relationship between EMT and paramedic scores in the population. The floor effect in this study was a result of truncating the scoring range of the measurement instrument rather than truncating the sample, thus it can be assumed that the floor effect is not related to the use of the convenience sample or associated sampling error. Because the scoring range of the sample with respect to the EMT examination matched the scoring range of the target population, the reduced variance associated with the restricted range is an unbiased estimate of the variance in the population and should not affect the interpretation of the results of the ANCOVA samples.

The mean item discrimination represents the ability of the examination to
discriminate between high and low performers. Ebel (1979) states that mean item discrimination indices above 0.30 are good, Haladyna (1997) suggested point biserial values greater than 0.20 are highly discriminating, and Kehoe (1995) suggests mean item discriminations less than 0.15 are inadequate and require revision of items to ensure adequate sensitivity to discriminate between high and low performers. The mean item discrimination for the EMT examination (0.17) is slightly lower than that reported for the paramedic examination (0.21). The lower mean discrimination associated with the EMT examination may be a result of the restriction of range on the scale of the EMT examination that effectively reduced the overall variance in scores in the sample when compared to all students who attempted the EMT examination during the same time period (Gulliksen, 1961). While the evidence of acceptable reliability and unidimensionality of both examinations are promising, the ability of these examinations to effectively discriminate between high and low performers may reduce their sensitivity as outcomes measures in the current study, especially in the presence of small effect sizes.

4.2 Descriptive Statistics

The mean paramedic examination score, standard deviations, minimum and maximum values, and kurtosis and skewness statistics for the three independent variables are presented in Table 14.
The mean student scores achieved on the paramedic examination appear to be very similar for VPE usage and non-VPE usage. Likewise, the mean student examination scores are similar for students reporting service type as fire-based or non–fire-based. There appears to be a significant difference in mean student examination scores with respect to gender. Males appear to achieve significantly higher scores than females when completing the paramedic examination. Using a quick-check heuristic, which suggests if the absolute value of a skewness and kurtosis statistic is greater than or equal to twice the magnitude of the standard error, then departure from normality exists. The distribution of paramedic scores by independent variable appear to be distributed normally for all groups, with the exception of gender. With respect to gender, violation of normality may
exist. Statistical tests of normality of paramedic examination scores by independent variable are presented in Section 4.5 of this chapter.

The mean EMT examination score, standard deviations, minimum and maximum values, and kurtosis and skewness statistics for the three independent variables are presented in Table 15.

<table>
<thead>
<tr>
<th>VPE</th>
<th>M*</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Skewness</th>
<th>SE</th>
<th>Kurtosis</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>76.69</td>
<td>4.61</td>
<td>70</td>
<td>91</td>
<td>.623</td>
<td>.090</td>
<td>-.256</td>
<td>.179</td>
</tr>
<tr>
<td>Non-Usage</td>
<td>76.48</td>
<td>4.66</td>
<td>70</td>
<td>94</td>
<td>.661</td>
<td>.034</td>
<td>-.163</td>
<td>.068</td>
</tr>
<tr>
<td>Service Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire-Based</td>
<td>76.36</td>
<td>4.56</td>
<td>70</td>
<td>94</td>
<td>.699</td>
<td>.049</td>
<td>-.084</td>
<td>.097</td>
</tr>
<tr>
<td>Non-Fire-Based</td>
<td>76.62</td>
<td>4.73</td>
<td>70</td>
<td>94</td>
<td>.623</td>
<td>.042</td>
<td>-.240</td>
<td>.084</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>76.40</td>
<td>4.64</td>
<td>70</td>
<td>94</td>
<td>.699</td>
<td>.036</td>
<td>-.076</td>
<td>.072</td>
</tr>
<tr>
<td>Female</td>
<td>76.86</td>
<td>4.71</td>
<td>70</td>
<td>91</td>
<td>.522</td>
<td>.065</td>
<td>-.442</td>
<td>.131</td>
</tr>
</tbody>
</table>

*Mean score reported on a raw score scale ranging from 70 - 100
n = 5966

Table 15: EMT Score Distribution by VPE, Service Type, and Gender

The mean student score achieved on the EMT examination appears to be similar for all groups and all levels within individual groups. Using the skewness and kurtosis heuristic described above, as anticipated in the earlier discussion concerning normality of the EMT examination scores (Chapter 3), the distribution of EMT examination scores in
each group appear to be skewed in the positive direction. Statistical tests of normality of EMT examination scores by independent variable are presented in Section 4.5 of this chapter.

4.3 Missing Data Analysis

The sample distribution and missing data by research variable received from the NREMT and Elsevier are presented in Table 16.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Missing Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPE</td>
<td>6802</td>
<td>0</td>
</tr>
<tr>
<td>Service Type</td>
<td>6057</td>
<td>745</td>
</tr>
<tr>
<td>Gender</td>
<td>6264</td>
<td>538</td>
</tr>
</tbody>
</table>

Table 16: Sample Distribution by Variable

The NREMT supplied a data set with a total sample of 6802 students drawn from 48 states. The states of Vermont and Wyoming did not have paramedic students testing during the inclusion period and therefore were not included in the sample. There were 745 (11%) students who failed to provide data relative to their service type during the NREMT application process and 538 (8%) failed to provide gender data. To determine the randomness of the missing data, a visual analysis of the sampling distributions of missing data, Levene’s test for equality of variance between missing and obtained data, and an independent t-test of differences in mean between missing and obtained data were
conducted. Figure 6, Table 17, and Table 18 present the findings of the analysis of missing data for the gender variable.

Figure 6: Distribution of Paramedic Score - Missing Gender Data

<table>
<thead>
<tr>
<th>F</th>
<th>Sig. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.412</td>
<td>0.12</td>
</tr>
</tbody>
</table>

*p<0.05

Table 17: Levene's Test for Equality of Variance - Missing Data: Gender

<table>
<thead>
<tr>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)*</th>
<th>Mean Difference</th>
<th>S. E. Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.795</td>
<td>6799</td>
<td>0.073</td>
<td>0.05</td>
<td>0.028</td>
<td>-0.005 - 0.105</td>
</tr>
</tbody>
</table>

*Dependent variable: Student score – paramedic examination

*p<0.05

n = 6802

Table 18: t-test Mean Paramedic Score Differences – Missing Data Gender

Visual comparison of the two sampling distributions in Figure 6 indicate there is
similar distribution of paramedic scores and no significant deviation from normality in each sampling distribution. Levene’s test indicated equal variances ($F = 2.412, p = 0.12$). Students providing gender information to the NREMT during the application process did not have significantly different paramedic scores ($M=1.423, SD = .008$) than did those who did not provide gender information to the NREMT ($M=1.474, SD = .28$), ($t(5799) = 1.795, p = 0.07$). The sample of students failing to provide gender information is not significantly different than the sample of students providing gender information with respect to mean paramedic examination score, sampling distribution, and variance of scores achieved on the paramedic examination. The missing gender data appear to be a random selection of males and females with no evidence of an underlying bias relative to the paramedic examination scores (Hair et al., 1998), suggesting gender data is missing completely at random and exclusion of this data from the study will not adversely impact interpretation of the results of the analysis.

Figure 7, Table 19, and Table 20 present the findings of the analysis of missing data for the service type variable.

![Histograms of Paramedic Scores](image)
Table 19: Levene's Test for Equality of Variance - Missing Data: Service Type

<table>
<thead>
<tr>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.044</td>
<td>0.833</td>
</tr>
</tbody>
</table>

Dependent variable: Student score – paramedic examination
*p<0.05
n = 6802

Table 20: t-test Mean Differences Responders and Non-Responders: Service Type

<table>
<thead>
<tr>
<th>T</th>
<th>df</th>
<th>Sig. (2-tailed)*</th>
<th>Mean Difference</th>
<th>S. E. Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.852</td>
<td>6799</td>
<td>0.394</td>
<td>0.021</td>
<td>0.024</td>
<td>-0.027, 0.068</td>
</tr>
</tbody>
</table>

Dependent variable: Student score – paramedic examination
*p<0.05
n = 6802

Visual comparison of the two sampling distributions in Figure 7 indicate there is similar distribution of paramedic scores and no significant deviation from normality in each sampling distribution. Levene’s test indicated equal variances ($F = 0.044, p = 0.833$). Students providing service type data to the NREMT during the application process did not have significantly different paramedic scores ($M=1.425, SD = .008$) than did those who did not provide service type information to the NREMT ($M=1.446, SD = .023$), ($t(6799) = 0.852, p = 0.394$). The sample of students failing to provide service type information is not significantly different than the sample of students providing service type information with respect to mean paramedic score, sampling distribution, and variance of scores achieved on the paramedic examination. These results suggest the service type data is missing at random and exclusion from the research will not
adversely impact interpretation of the results of the analysis.

Like the missing data for gender, the missing service type data appear to be a random selection of fire-based and non–fire-based students with no evidence of an underlying bias relative to the paramedic examination scores (Hair et al., 1998). These findings suggest service type data is missing completely at random and exclusion of this data from the study will not adversely impact interpretation of the results of the analysis.

4.4 Evaluation of ANCOVA Assumptions

The current study employed Analysis of CoVariance (ANCOVA) to test the hypothesis regarding effect of the use of computer-based clinical simulations relative to student performance on the paramedic examination. Before conducting the analysis, adherence to the underlying assumptions of ANCOVA were verified. If any of the assumptions were violated, the results of the analysis should be interpreted cautiously because the observed $F$ value may have been based on a population that is different from the unbiased population used to determine the theoretical $F$ distribution.

Universal assumption for any analysis of variance (ANOVA and ANCOVA) is that the sample is random in nature. Random assignment was not a possibility in the quasi-experimental design because of the retrospective analysis of existing data. An additional assumption is that the dependent/covariate data is interval level data. If the assumption of interval-level data is not met, variance cannot be calculated because the analytical model relies on measured treatment means and between group variances. In this study, the data for the student score on the paramedic examination is interval level data representing the student examination score on a continuous scale ranging from -3.0
to 3.0. The covariate data for the student score achieved on the EMT examination is interval data representing the student examination score on a continuous scale ranging from 70 to 100 score achieved when completing the EMT examination.

The assumption of independence requires that the observations are independent. For this study, the examination score achieved by one individual must not influence another individual’s examination score. Conversely, an individual’s examination score must not be affected by the examination scores of the other individuals included in the study. Due to the convenience sampling and the nonequivalent control group design, students are nested within paramedic classes, and paramedic classes are nested within accredited paramedic education programs. This presents a threat to the independence assumption because paramedic faculty may utilize patient presentations common to their location, particularly when program locations differ by population centers, (i.e., urban population centers versus rural population centers). This is unlikely, as each accredited paramedic program is required to use a nationally standardized curriculum that specifies student competencies in terms of clearly defined patient care procedures in equally defined patient presentations. The requirement for a nationally standardized curriculum controlled for this threat to the assumption of independence. In addition, the measurement of the student scores on the NREMT EMT examination and the NREMT paramedic examination were conducted individually at secure testing centers, which were independent of the demographics of the student population, patient population, location of the education program, location of the testing center, and date/time of the measurement.

The assumption of is normality suggests each dependent variable is normally
distributed within each independent variable. A Q-Q plot test of the dependent variable and covariate were conducted to assess for univariate normality. Observations for the dependent variable and the covariate were ordered in increasing magnitude by independent variable and then plotted against their expected normal quantiles. Plots representing a straight line, or nearly a straight line, suggest the assumption of univariate normality is reasonable. Histograms of the distribution of the dependent variable and covariate were evaluated as well

Figures 8 through 14 present the histograms and Q-Q plots of the national paramedic credentialing scores across each level of the three independent variables.

Figure 8: Histogram and Q-Q Plot – Paramedic Examination

Figure 9: Histogram and Q-Q Plot Paramedic Score – Non-VPE Usage
Figure 10: Histogram and Q-Q Plot Paramedic Score – VPE Usage

Figure 11: Histogram and Q-Q Plot Paramedic Score – Fire-Based

Figure 12: Histogram and Q-Q Plot Paramedic Score – Non–Fire-Based
Visual inspection of the histograms and the Q-Q plots of normality for the paramedic examination indicate no significant deviations from normality of distribution of paramedic examination scores across the 3 independent variables. To supplement these visual inspections, the 95% confidence interval surrounding the skew and kurtosis statistic for each factor level was calculated to test the following null hypothesis: The skew and kurtosis statistics are not significantly different from the value 0. The results are presented in Table 21.
The results presented in Table 21 indicate the analysis of the 95% confidence interval surrounding the skew and kurtosis statistics for both levels of the VPE variable, both levels of the service type variable, and the female level of the gender variable included 0. Thus, the null hypothesis is not rejected and the assumption of normal distribution of paramedic examination scores across all levels of the VPE, service type, and the female level of the gender is retained. The 95% confidence interval surrounding the kurtosis statistics for male included 0; however, the 95% confidence interval surrounding the skew statistics for male failed to include 0. Thus, the null hypothesis for the male level of the gender is rejected and normal distribution of paramedic examination scores cannot be assumed for the male level of gender.

The $F$ test is robust to deviations from normality (Lindman, 1974; Anderson,
In general, the $F$ statistic is less robust to deviations from normality related to kurtosis than skewness. The $F$ statistics tends to be downward biased if the distribution is leptokurtic and upward biased in the presence of a platykurtic distribution. However, skewness does not usually have a significant impact on the $F$ statistic (Lindman, 1974). It is important to remember that ANCOVA is robust to violations of normality, particularly for large samples (Hair et al., 1998). The current study included 4570 males, and therefore violation of normality as a result of skewness should not bias the interpretations of the $F$ statistic related to this variable.

Figures 15 through 21 present the histograms and Q-Q plots of the EMT examination scores across each level of the three independent variables.

Figure 15: Histogram and Q-Q Plot – EMT Examination

Figure 16: Histogram and Q-Q Plot EMT Score – Non-VPE Usage
Figure 17: Histogram and Q-Q Plot EMT Score – VPE Usage

Figure 18: Histogram and Q-Q Plot EMT Score – Fire-Based

Figure 19: Histogram and Q-Q Plot EMT Score – Non–Fire-Based

Figure 20: Histogram and Q-Q Plot EMT Score – Female
Visual inspection of the histograms and the Q-Q plots of normality indicate deviation from univariate normality across all groups and all levels within groups. As discussed in Chapter 3, Section 3.6, this was expected because of the attenuation of the EMT examination scoring scale for this study. To supplement these visual inspections, the 95% confidence interval surrounding the skew and kurtosis statistics for each factor level was calculated to test the following null hypothesis: The skew and kurtosis statistics are not significantly different from the value 0. The results are presented in Table 22.
<table>
<thead>
<tr>
<th>VPE Usage</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>SE</td>
</tr>
<tr>
<td>Usage</td>
<td>.623</td>
<td>.090</td>
</tr>
<tr>
<td>Non-Usage</td>
<td>.661</td>
<td>.034</td>
</tr>
<tr>
<td>Service Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Service</td>
<td>.699</td>
<td>.049</td>
</tr>
<tr>
<td>Non–Fire-Based</td>
<td>.623</td>
<td>.042</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>.699</td>
<td>.036</td>
</tr>
<tr>
<td>Female</td>
<td>.522</td>
<td>.065</td>
</tr>
</tbody>
</table>

Table 22: Analysis of Normality: Skew and Kurtosis Statistics – EMT Score

The results presented in Table 22 indicate the analysis of the 95% confidence interval surrounding the skewness statistics for all groups and all levels within the groups failed to include 0, suggesting deviation from univariate normality. As expected, the EMT examination score appears to be skewed in the positive direction for all analytic cells included in this study. An analysis of the 95% confidence interval surrounding the kurtosis statistic for VPE usage, fire-based service type, and male gender contained the value 0; therefore, the null is not rejected and assumes the distribution for these variables is mesokurtotic. However, the 95% confidence interval surrounding non-VPE usage, non–fire-based service type, and female gender did not include the value 0; therefore, the null is rejected. Further analysis indicates the kurtosis statistic for each of these variables is negative, reflecting platykurtic distribution. As mentioned earlier in the discussion on
normality, several researchers report the $F$ test is robust to deviations from normality (Lindman, 1974; Anderson, 1984; Hair et al, 1998). However, Lindman (1974) reports the $F$ statistic is less robust if violations of normality are associated with kurtosis. The $F$ statistics tends to be downward biased if the distribution is leptokurtic, increasing the probability of a Type I error. Conversely, the $F$ statistic is upward biased in the presence of a platykurtic distribution, increasing the probability of a Type II error. It should be noted that several studies using simulated data representing a variety of non-normal distributions did not result in true increased Type I errors rates, and those that did, typically occurred in a conservative direction (Keppel and Wickens, 2004).

The assumption of homogeneity of variance requires that the variance of each group within the study be equivalent. If sampling resulted in approximately equivalent group sizes, the impact of violation of this assumption is minimal. If the ratio of difference in size between the largest group and the small group is greater than 1.5, the “researcher should test and correct for unequal variances” (Hair, 1998, p. 348). Box’s M is typically used to test for the assumption of homogeneity of variance-covariance matrices. Box's M is extremely sensitive to violations of the assumption of normality. For this reason, it is recommended to test at the $p=0.001$ level, especially when sample sizes are unequal (Meyers, Gamst, and Guarino, 2006).

The Box’s M test yielded a nonsignificant result at .05 ($\text{Box’s M} = 27.889, p = .148$), suggesting an equivalence of the variance-covariance matrices across groups. This result was unexpected by the researcher because Box’s M test is extremely sensitive to violations of the multivariate normality assumption, which was evident in the current study with the respect to distribution of the EMT examination scores.
In addition to these assumptions, the use of ANCOVA requires the assumptions of independence of the covariate from the treatment, linear relationship between the dependent variable and the covariate, homogeneity of regression slopes, and absence of high multicollinearity. The design of the current study ensured the student’s EMT examination score was independent of the use of computer-based clinical simulations. All students included in this study completed the EMT examination between the inclusive dates of February 22, 1979 and December 29, 2006. The use of the VPE for this study was restricted to the inclusive dates of July 1, 2007 and June 30, 2008. Since the EMT examination data was collected prior to the use of VPE, it can be assumed that the EMT examination scores are independent of the use of VPE.

A regression analysis of EMT examination scores (IV) and paramedic examination scores (DV) was used to assess for a linear relationship between the variables. The results are presented in Table 23.

<table>
<thead>
<tr>
<th>Unstandardized Coefficient</th>
<th>95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>EMT Examination Score</td>
<td>0.056</td>
</tr>
</tbody>
</table>

Dependent variable: Student score – paramedic examination

*p<0.05

n = 5966

Table 23: Regression Coefficient – EMT Exam Score by Paramedic Exam Score

The results for the check of assumption of linearity test, t (5965) = 35.843, p < .05, indicate a statistically significant linear relationship between EMT examination score and paramedic examination score.
The assumption of homogeneity of regression slopes was assessed using ANOVA to test for significant interaction between each independent variable and student EMT examination scores. The results are presented in Tables 24 through 26. In addition, scatter plots of EMT examination scores and paramedic examination scores overlaid with fit lines for each level of independent variable were used to visually inspect the homogeneity of regression slopes. The results are presented in Figures 22 through 24.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPE</td>
<td>184.317</td>
<td>2</td>
<td>92.158</td>
<td>287.499</td>
<td>0.000*</td>
</tr>
<tr>
<td>Examination Score</td>
<td>167.289</td>
<td>1</td>
<td>167.289</td>
<td>521.878</td>
<td>0.000*</td>
</tr>
<tr>
<td>VPE by Examination Score</td>
<td>0.194</td>
<td>1</td>
<td>0.194</td>
<td>0.606</td>
<td>0.436</td>
</tr>
<tr>
<td>Error</td>
<td>1911.128</td>
<td>5962</td>
<td>0.321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14409.789</td>
<td>5966</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 24: Two-Way ANOVA – EMT Exam Score by VPE Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Type</td>
<td>185.89</td>
<td>2</td>
<td>92.945</td>
<td>290.472</td>
<td>.000*</td>
</tr>
<tr>
<td>Examination Score</td>
<td>396.673</td>
<td>1</td>
<td>396.673</td>
<td>1239.681</td>
<td>.000*</td>
</tr>
<tr>
<td>Service Type by Examination Score</td>
<td>0.208</td>
<td>1</td>
<td>0.208</td>
<td>0.649</td>
<td>0.421</td>
</tr>
<tr>
<td>Error</td>
<td>1907.721</td>
<td>5962</td>
<td>0.320</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14409.789</td>
<td>5966</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 25: Two-Way ANOVA – EMT Exam Score by Service Type Variable
Table 26: Two-Way ANOVA – EMT Examination Scores by Gender Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>189.987</td>
<td>2</td>
<td>94.993</td>
<td>299.239</td>
<td>0.000*</td>
</tr>
<tr>
<td>Examination Score</td>
<td>320.425</td>
<td>1</td>
<td>320.425</td>
<td>1009.373</td>
<td>0.000*</td>
</tr>
<tr>
<td>Gender by Examination Score</td>
<td>0.708</td>
<td>1</td>
<td>0.708</td>
<td>2.229</td>
<td>0.135</td>
</tr>
<tr>
<td>Error</td>
<td>1892.635</td>
<td>5962</td>
<td>0.317</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14409.789</td>
<td>5966</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 22: Assumption of Homogeneity of Slopes – VPE

Figure 23: Assumption of Homogeneity of Slopes – Service Type
Figure 24: Assumption of Homogeneity of Slopes – Gender

Based on the results of the check of assumption of homogenous regression slopes for VPE by EMT examination score interaction, $F(1,5962) = 0.606$, $p > .05$, the null hypothesis is not rejected and the assumption of homogenous regression slopes is retained. Based on the results of the check of assumption of homogenous regression slopes for service type by EMT examination score interaction, $F(1,5962) = 290.472$, $p > .05$, the null hypothesis is not rejected and the assumption of homogenous regression slopes is retained. Based on the results of the check of assumption of homogenous regression slopes for gender by EMT examination score interaction, $F(1,5962) = 299.239$, $p > .05$, the null hypothesis is not rejected and the assumption of homogenous regression slopes is retained. The scatter plots of the EMT examination scores and paramedic examination scores by independent variable confirm the assumption of equality of slopes.

Multicollinearity is a measure of redundancy associated with combinations of dependent variables and covariates. Multicollinearity was evaluated by assessing the tolerance and the variance of inflation factor (VIF). Tolerance of a variable is the
Coefficient of determination for the prediction of that variable by the other predictor variables. Tolerance values approaching zero indicate high collinearity. The VIF measures the effect of other predictor variables on a regression coefficient and expresses the degree to which collinearity among the predictors degrades the precision of an estimate. Typically a VIF value greater than 10 is of concern. Presence of high multicollinearity represents redundant dependent variables and ultimately decreases the statistical efficiency and power of the ANCOVA test. Analysis of a regression model using EMT examination scores, VPE usage, service type, and gender as predictors of scores on the paramedic examination was used to assess the amount of collinearity present between the EMT examination scores and the paramedic examination scores. Table 27 presents the results of a linear regression analysis, tolerance statistic, and variance inflation factor.

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficient</th>
<th>Correlations</th>
<th>Collinearity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>t</td>
</tr>
<tr>
<td>EMT Score</td>
<td>0.057</td>
<td>0.002</td>
<td>36.30*</td>
</tr>
<tr>
<td>VPE</td>
<td>0.012</td>
<td>0.022</td>
<td>0.562</td>
</tr>
<tr>
<td>Service Type</td>
<td>-0.200</td>
<td>0.015</td>
<td>-1.331</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.124</td>
<td>0.018</td>
<td>-6.913*</td>
</tr>
</tbody>
</table>

*Dependent variable: Student score – paramedic examination
*p<0.05
n = 5966

Table 27: Analysis of Collinearity

The Pearson correlation for the EMT examination score with respect to the
paramedic examination score is 0.421. This indicates approximately 18% of the variance in the paramedic examination score can be explained by the EMT examination score. The partial correlation for the EMT examination is 0.425. This represents the correlation between the EMT examination score and the paramedic examination score, controlling for other independent variables (VPE usage, service type, and gender).

The tolerance for a variable is $1 - R^2$ for the regression of that variable on all the other independents, ignoring the dependent. When tolerance is close to 0, multicollinearity of that variable with other independent variables should be suspected. All independent variables in the regression model are significantly greater than 0, suggesting the absence of high multicollinearity. The variance inflation factor (VIF) is the reciprocal of tolerance. VIF values greater than 10 suggest presence of high multicollinearity (Hair et al., 1998). The VIF values of the independent variables in the regression model range from 1.002 to 1.08 further confirm the absence of high multicollinearity.

4.5.4 ANCOVA Results

A three-way ANCOVA was performed. The dependent variable was paramedic examination scores attained by students, with the EMT examination scores serving as the covariate. The independent variables included in the analysis were VPE usage, service type, and gender. The results of the ANCOVA analysis are presented in Table 28.
Table 28: Analysis of Covariance for VPE, Service Type, and Gender

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>F</th>
<th>Sig.</th>
<th>$\eta^2_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMT Examination Score</td>
<td>412.740</td>
<td>1</td>
<td>1303.457</td>
<td>0.000*</td>
<td>0.180</td>
</tr>
<tr>
<td>VPE</td>
<td>0.024</td>
<td>1</td>
<td>0.075</td>
<td>0.784</td>
<td>0.000</td>
</tr>
<tr>
<td>Service Type</td>
<td>2.401</td>
<td>1</td>
<td>7.583</td>
<td>0.006*</td>
<td>0.001</td>
</tr>
<tr>
<td>Gender</td>
<td>3.742</td>
<td>1</td>
<td>11.818</td>
<td>0.001*</td>
<td>0.002</td>
</tr>
<tr>
<td>VPE by Service Type</td>
<td>0.395</td>
<td>1</td>
<td>1.247</td>
<td>0.264</td>
<td>0.000</td>
</tr>
<tr>
<td>VPE by Gender</td>
<td>0.291</td>
<td>1</td>
<td>0.919</td>
<td>0.338</td>
<td>0.000</td>
</tr>
<tr>
<td>Service Type by Gender</td>
<td>0.289</td>
<td>1</td>
<td>0.911</td>
<td>0.340</td>
<td>0.000</td>
</tr>
<tr>
<td>VPE by Service Type by Gender</td>
<td>0.505</td>
<td>1</td>
<td>1.595</td>
<td>0.207</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>1886.287</td>
<td>5957</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14409.789</td>
<td>5966</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*MSE = 0.317
*R Squared = .869 (Adjusted R Squared = .869)

4.5.4.1 Results of Covariate Effects

The ANCOVA indicated a significant effect for the covariate, EMT examination score ($F(1, 5957) = 1303.457, p < 0.05$), which accounted for 18% of the variability in the student score on the paramedic examination. These results are consistent with the variability identified in the analysis of multicollinearity. In addition, the presence of homogenous regression slopes suggest the relationship between EMT examination scores and paramedic examination scores are consistent in each factorial cell.
4.5.4.2 Main Effect of VPE

Analysis of main effects revealed no significant effect on scores achieved by students on the paramedic examination, after controlling for scores on the EMT examination, with respect to usage and non-usage of VPE (F(1,5957) = 0.075, p > 0.05. Therefore, the null hypothesis is not rejected. The adjusted mean score for paramedic students using VPE was 1.400 (SE = 0.31), which was slightly lower than the adjusted mean score for paramedic students not using VPE (1.409 (SE = 0.11)); however, there was no measurable effect (\(\eta^2_p = .000\)).

These findings were unexpected as the theoretical foundations of reflective learning, E-space, and virtual practicums suggest use of VPE would improve student outcomes. There are several possible explanations for these negative findings. The use of a convenience sample, resulting in an unbalanced factorial design may reduce the overall power of the analysis to detect a difference. As noted in the results, the standard error associated with VPE usage is almost 3 times larger than that of non-VPE usage. In addition, the non-VPE variable displayed a platykurtic distribution even in the presence of a large sample (n = 5223). These combined issues suggest evidence of a sampling error related to estimates of the means and may have resulted in a reduction of the sensitivity of the test to detect a difference in mean scores. An additional concern with the convenience sample is that the use of VPE was not determined at random; therefore, the variables related to the choice of faculty to purchase and use the VPE product could not be evaluated in the current study. While there do not appear to be systematic variances associated with the student variables included in this study, the program location, policies, faculty preparation, and institutional finances may have a significant impact on
the use of VPE product.

According to Magee (2006), the educational approach utilized by the educator has a significant effect on student success when interacting with educational simulations. Because the study was a retrospective analysis of existing data, providing instructions to faculty on the implementation of the VPE product and the use of appropriate pedagogy related to simulation technology was not possible. As reported by Ruple et al. (2005), the process of providing education within the paramedic discipline is typified by educators who follow a scripted lesson plan included in nationally standardized curricula using a traditional classroom approach, or transmission model. This mismatch between the objectivist approach of the traditional EMS classroom and the constructivist design of the VPE product may have negated any positive impact on student performance that would been expected based on theories of Kolb, Schon, and Boisot.

4.5.4.3 Main Effect of Service Type

Analysis of covariance on paramedic examination scores, adjusted for EMT examination scores, revealed a significant effect for service type ($F_{1,5957} = 7.583, p < 0.5, \eta^2_p = .001$). Adjusted mean scores were significantly higher for fire-based paramedic students (Adj. $M = 1.45, SE = 0.029$) than for non-fire-based paramedic students (Adj. $M = 1.359, SE = 0.016$). While there is a statistically significant effect for service type, the small effect size ($\eta^2_p = .001$) suggests this difference accounts for less than 1% of the variance in student scores on the paramedic examination.

These findings are consistent with those previously reported by Dickison et al. (2006) and Fernandez et al. (2008). Brown, Dickison, Misselbeck, and Levine (2002)
indicated that pay and benefits were important or very important to more than 95% of paramedics reporting. Among settings that typically employ EMS providers, fire departments typically offer the highest salaries and the most generous employee benefits package to newly hired paramedics (Monasky, 2002; HealthAnalytics, 2001). In addition, some fire departments require successful completion of the paramedic examination for continued employment and/or promotion. These separate findings suggest that extrinsic motivators such as salary, benefits, promotion, and continued employment may be motivators for student success on the paramedic examination.

4.5.4.4 Main Effect of Gender

Analysis of covariance on paramedic examination scores, adjusted for EMT examination scores, revealed a significant effect for gender (\(F_{1,5957} = 11.818, p < 0.5, \eta_p^2 = .002\)). Adjusted mean scores were significantly higher for male (Adj. M = 1.461, SE = 0.013) than for female (Adj. M = 1.348, SE = 0.03). While there is a statistically significant effect for gender, the small effect size (\(\eta_p^2 = .002\)) suggests that this difference accounts for less than 1% of the variance in student scores on the paramedic examination.

These finding are consistent with those previously reported by Dickison et al. (2006). Several studies have identified structural, developmental, and performance difference between male and female brains (Gur, Turestky, Matsui, Yan, Bilker, Hughett, and Gur, 1999; Gassaniga, Ivry, and Mangun, 2002; Cahill, 2005; and Kimura, 1992). In addition, research related to gender differences in examination performance has indicated males typically score higher on mathematics and science achievement examinations than
females (Mullis et al., 2000; Bellar and Gafni, 1996; Hyde, Fennema, and Lamon, 1990; Lumis and Stevenson, 1990; Benbow, 1988). The findings of this study may be related to the content of paramedic education programs, which is predominantly on knowledge of anatomy, physiology, and pathophysiology. Additionally, a significant portion of the curriculum is devoted to pharmacology, which includes mathematics associated with the administration of emergency medications. This strong focus on mathematics and science in the paramedic curriculum may be the contributing factor to the disparity of student performance with respect to gender.

4.5.4.5 Interaction Effect of VPE Usage and Service Type

Analysis of covariance on paramedic examination scores, adjusted for EMT examination scores, did not reveal a significant interaction effect for VPE and service type ($F(1, 5957) = 1.247, p > 0.05$). Adjusted mean scores and confidence intervals are presented in Table 29.

<table>
<thead>
<tr>
<th>VPE Usage</th>
<th>Type of EMS Service</th>
<th>Mean</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPE</td>
<td>Fire-Based</td>
<td>1.464</td>
<td>0.055</td>
<td>1.357 - 1.571</td>
</tr>
<tr>
<td>Non–Fire-Based</td>
<td></td>
<td>1.336</td>
<td>0.029</td>
<td>1.279 - 1.394</td>
</tr>
<tr>
<td>No VPE Usage</td>
<td>Fire-Based</td>
<td>1.436</td>
<td>0.020</td>
<td>1.398 - 1.475</td>
</tr>
<tr>
<td></td>
<td>Non–Fire-Based</td>
<td>1.382</td>
<td>0.011</td>
<td>1.361 - 1.404</td>
</tr>
</tbody>
</table>

*Adjusted mean score reported on a logit scale ranging from −3.00 to 3.00

Table 29: Adjusted Means for VPE and Service Type
While there was no evidence of a statistically significant interaction, when the interaction was plotted with service type on the baseline, there appears to be a disordinal interaction upon visual inspection (Figure 25).

Figure 25: Interaction of VPE Usage and Service Type

Table 29 shows that fire-based paramedics increased the overall mean score by 0.028 logits when using VPE while matriculating through the paramedic education program, while the non–fire-based paramedic overall mean score decreased 0.046 logits. When looking at the size of the error associated with the measurement in each factorial cell, it is clear that the error in measurement associated with VPE usage, regardless of service type, is more than 2 times that associated with non-VPE usage. This may suggest that even though the Box’s M indicated equality of variance/covariance matrices, the smaller sample size of VPE usage (n = 743) versus the larger sample size of non-VPE usage (n = 5223), appears to have allowed for an increase of measurement error of cells
containing VPE usage. This increase in error may have resulted in a decrease of sensitivity to detect an interaction, if it existed. Therefore, these nonsignificant interaction results need to be interpreted cautiously. Future research should focus on designs that are truly random and completely balanced to help overcome issues related to sampling error and power.

It is equally possible that certain extrinsic motivational factors, as discussed earlier in the study, might have an impact on the commitment the fire-based paramedic placed on study regimes. In addition, paramedic fire departments are typically located in urban and metropolitan areas, which would result in the fire-based paramedic having an increased exposure to patient interactions. These patient interactions would have occurred during their matriculation through the education program and may have helped the fire-based paramedic student to receive the debriefing and remediation from paramedic colleagues that appeared to be lacking in the educational implementation of the clinical simulation product. Because the non–fire-based paramedic may not have had the advantage of increased interaction with patients and paramedic colleagues, they would have relied primarily on the education system to provide the debriefing and remediation necessary for successful implementation of computer-based clinical simulation within their educational experience. This is not to suggest that use of VPE resulted in degradation of paramedic scores in this group, rather that scores in this group were not significantly impacted by use of VPE and any decrease is most likely associated with the sample size and measurement error discussed previously.

4.5.4.6 Interaction Effect of VPE Usage and Gender
Analysis of covariance on paramedic examination scores, adjusted for EMT examination scores, did not reveal a significant interaction effect for VPE usage and gender (F(1, 5957) = 0.919, p > 0.05). Adjusted mean scores and confidence intervals are presented in Table 30.

<table>
<thead>
<tr>
<th>VPE Usage</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>1.473</td>
<td>0.024</td>
<td>1.426 - 1.519</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.328</td>
<td>0.057</td>
<td>1.215 - 1.440</td>
</tr>
<tr>
<td>No VPE Usage</td>
<td>Male</td>
<td>1.450</td>
<td>0.009</td>
<td>1.433 - 1.467</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.368</td>
<td>0.021</td>
<td>1.328 - 1.409</td>
</tr>
</tbody>
</table>

*Adjusted mean score reported on a logit scale ranging from −3.00 to 3.00
table 30: Adjusted Means for VPE and Gender

As with the previous discussion of interaction effect between VPE usage and service type, there was no evidence of a statistically significant interaction between VPE usage and gender, but when the interaction was plotted with gender on the baseline, there appears to be a disordinal interaction upon visual inspection (see Figure 26). While not statistically significant, the decrease in national paramedic examination scores for females using VPE is surprising. Neither Kolb nor Boisot have reported disordinal impact of experiential learning or epistemological space related to gender.

While several studies have identified cognitive differences in male and female brains (Gur, Turestky, Matsui, Yan, Bilker, Hughett, and Gur, 1999; Gassaniga, Ivry, and Mangun 2002; Cahill, 2005; and Kimura, 1992), these differences appear to be more
prominent in preadolescence than in early adulthood (Sousa, 2006). These researchers report that females perform better on tasks requiring perceptual speeds, identifying attributes of objects, and verbal fluency. When considered in combination with Atkins and Murphy’s (1993) assertion that the ability of a student to: (1) examine how a situation has affected him or her; (2) communicate a comprehensive account of the experience; and (3) synthesize and integrate information are essential for successful reflective thinking, it is reasonable to assume females would benefit from use of simulations in education.

Figure 26: Interaction of VPE and Gender

Similar to the discussion in Section 4.5.4.2, the discrepancy between error of measurement associated with VPE usage and non-VPE usage continues to be disparate. Again, the difference in error is more than 2 times higher for VPE usage, suggesting the sample size achieved using the convenience sample may have been insufficient to create
the sensitivity to detect an interaction effect, if one existed. This potential in decreased sensitivity may have been further complicated by the combination of a negative skew in male paramedic examination scores and the platykurtic distribution in the female EMT examination scores. As noted in Table 23, the error in measurement for female mean scores, regardless of VPE usage, is consistently more than 2 times the error associated with mean scores for males. Because females are tremendously underrepresented in the paramedic student population, future studies should consider a sampling methodology that over samples the female population to help overcome issues with increased error as a result of small sample sizes. Again, the finding of nonstatistically significant interaction should be interpreted cautiously.

If there is some veracity to the discussion of explanations for a disordinal interaction of VPE and service type, then it is reasonable to generalize these effects to gender as well. The portion of males to females is significantly higher in the fire service when compared to the non–fire-based service. This higher proportion of males would also result in a higher proportion of males benefiting from the increased patient/colleague interactions and mentoring opportunities associated with fire department, as well as the positive effects of extrinsic motivators. This is not to suggest that use of VPE resulted in degradation of paramedic scores in females, rather that females scores were not significantly impacted by use of VPE and any decrease is most likely associated with the sample size and measurement error discussed previously.

4.5.4.6 Interaction Effect of Service Type and Gender

Analysis of covariance on paramedic examination scores, adjusted for EMT
examination scores, did not reveal a significant interaction effect for service type and gender \((F(1, 5957) = 0.911, p > 0.05)\). These findings are unexpected when viewed in the context of main effects for both service type and gender. Adjusted mean scores and confidence intervals are presented in Table 31.

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Fire-Based</td>
<td>Male</td>
<td>1.491</td>
<td>0.017</td>
<td>1.457</td>
<td>1.524</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.409</td>
<td>0.055</td>
<td>1.300</td>
<td>1.518</td>
</tr>
<tr>
<td>Non–Fire-Based</td>
<td>Male</td>
<td>1.432</td>
<td>0.019</td>
<td>1.395</td>
<td>1.468</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.287</td>
<td>0.025</td>
<td>1.237</td>
<td>1.336</td>
</tr>
</tbody>
</table>

*Adjusted mean score reported on a logit scale ranging from –3.00 to 3.00

Table 31: Adjusted Means for Service Type and Gender

When the interaction was plotted with gender on the baseline, there appears to be a disordinal interaction on visual inspection, as evidenced by the dissimilar slopes of male and female mean scores across levels of service type (see figure 27). The mean score difference between fire-based and non–fire-based paramedic students was 0.059, while the differences between service type for female paramedic students was more than twice as large (0.122).
The errors associated with the small female sample size continue to present problems with the interpretation of these interactions. The effect of the small sample on the size of error may be most prominent in the service type by gender interaction. In the current study, males reporting fire-based service ($n = 2288$) outnumbered females reporting fire-based service almost 9 to 1, compared to an approximately 2 to 1 ratio of males ($n = 2282$) to females ($n = 1137$) reporting non–fire-based service. While most researchers indicate ANCOVA is robust to violations of assumptions with large sample sizes ($> 30$), these differences in cell sizes appear to have significantly impacted the amount of error associated with measurement of the mean paramedic examination scores by gender. Table 24 indicates that the difference in measurement error is more than 3 times higher for females than males when the student reported fire-based service type. However, when the service type was reported as non–fire-based, the difference in
measurement error approached equivalence. It is once again possible that an error in measurement associated with female representation in the study may have resulted in an increased probability of committing a Type II error.

4.5.4.7 Interaction Effect VPE Usage and Service Type and Gender

Analysis of covariance on paramedic examination scores, adjusted for EMT examination scores, did not reveal a significant interaction effect for VPE usage and service type and gender (F (1,5957) = 1.595, p > 0.05). Adjusted mean scores and confidence intervals are presented in Table 32.

<table>
<thead>
<tr>
<th>VPE Usage</th>
<th>Service Type</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-Based</td>
<td>Male</td>
<td>1.541</td>
<td>0.032</td>
<td>1.479</td>
<td>1.604</td>
</tr>
<tr>
<td>Female</td>
<td>1.386</td>
<td>0.104</td>
<td>1.181</td>
<td>1.591</td>
<td></td>
</tr>
<tr>
<td>Non-Fire-Based</td>
<td>Male</td>
<td>1.404</td>
<td>0.035</td>
<td>1.335</td>
<td>1.472</td>
</tr>
<tr>
<td>Female</td>
<td>1.269</td>
<td>0.047</td>
<td>1.177</td>
<td>1.361</td>
<td></td>
</tr>
<tr>
<td>No VPE Usage</td>
<td>Fire-Based</td>
<td>Male</td>
<td>1.440</td>
<td>0.013</td>
<td>1.416</td>
</tr>
<tr>
<td>Female</td>
<td>1.432</td>
<td>0.037</td>
<td>1.359</td>
<td>1.505</td>
<td></td>
</tr>
<tr>
<td>Non-Fire-Based</td>
<td>Male</td>
<td>1.460</td>
<td>0.013</td>
<td>1.435</td>
<td>1.484</td>
</tr>
<tr>
<td>Female</td>
<td>1.305</td>
<td>0.018</td>
<td>1.270</td>
<td>1.340</td>
<td></td>
</tr>
</tbody>
</table>

*Adjusted mean score reported on a logit scale ranging from –3.00 to 3.00

Table 32: Adjusted Means for VPE and Service Type and Gender

The 3-way interaction was plotted using a graph depicting VPE usage and a separate graph depicting non-VPE usage. Both graphs were plotted with gender on the
baseline to allow for comparison (Figures 28 and 29).

![Figure 28: Interaction of VPE Usage and Service Type and Gender](image)

![Figure 29: Interaction of Non-VPE Usage and Service Type and Gender](image)

Based on the previous discussions of 2-way interactions, it is not surprising that there appears to be a disordinal 3-way interaction, even in the absence of statistical
significance. The apparently large difference in mean paramedic examination score, based on gender across level of service type, must be interpreted very cautiously as the error in measurement identified earlier is increased in the 3-way interaction where the smallest sample size (VPE by fire-based by female) was 29 and the standard error around the mean score for the group was more than 7 times higher than the groups with the smallest standard error (VPE usage by fire-based by male and non-VPE usage by non–fire-based by male).

4.6 Focus Group Results

The end-user focus group was conducted by the Elsevier EMS editorial and marketing staff for the purpose of investigating how the VPE product was used within the paramedic education environment and to elicit information relative to improving the product in subsequent updates. Twelve paramedic faculty were invited to participate, based on their purchase and prior use of the VPE product during the inclusive dates of January 1, 2007 and December 31, 2007. Observations recorded during the focus group interviews were analyzed and a report was prepared and approved by the research team and the focus group participants. The final focus group report provided by the Elsevier research team was reviewed and analyzed to determine if coaching, scaffolding, debriefing, and remediation pedagogies were utilized by the paramedic faculty in the implementation of the VPE product.

4.6.1 Focus Group Sample

Nine of the twelve invited participants (75%) attended the focus group interviews.
On arrival, various demographic characteristics of the focus group participants were obtained. The final report did not contain information on the characteristics relative to the 3 invited programs that chose not to attend the focus group meeting. Table 33 provides a summary of the study inclusion characteristics for each participant attending the focus group meeting, as well as demographic characteristics obtained during the focus group process.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Education Level</th>
<th>Program Environment</th>
<th>Program Location</th>
<th>Students per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>Male</td>
<td>Masters</td>
<td>4-yr College</td>
<td>Illinois</td>
<td>20</td>
</tr>
<tr>
<td>Beta</td>
<td>Female</td>
<td>Associate</td>
<td>Career School</td>
<td>Texas</td>
<td>75</td>
</tr>
<tr>
<td>Gamma</td>
<td>Female</td>
<td>Baccalaureate</td>
<td>Career School</td>
<td>Massachusetts</td>
<td>60</td>
</tr>
<tr>
<td>Delta</td>
<td>Male</td>
<td>Some College</td>
<td>Fire Service</td>
<td>Ohio</td>
<td>15</td>
</tr>
<tr>
<td>Epsilon</td>
<td>Male</td>
<td>Baccalaureate</td>
<td>Community College</td>
<td>California</td>
<td>30</td>
</tr>
<tr>
<td>Zeta</td>
<td>Male</td>
<td>Some College</td>
<td>EMS Academy</td>
<td>Virginia</td>
<td>30</td>
</tr>
<tr>
<td>Eta</td>
<td>Female</td>
<td>Associate</td>
<td>Community College</td>
<td>Nevada</td>
<td>25</td>
</tr>
<tr>
<td>Theta</td>
<td>Male</td>
<td>Some College</td>
<td>Fire Service</td>
<td>New York</td>
<td>20</td>
</tr>
<tr>
<td>Iota</td>
<td>Male</td>
<td>Some College</td>
<td>Fire Service</td>
<td>Georgia</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 33: Focus Group Characteristics

The focus group consisted of six males (67%) and three females (33%) who had teaching responsibilities within a paramedic education program. This is consistent with the distribution of paramedic gender nationally (69% male, 31% female) reported by Ruple et al. (2005). One focus group participant (11%) had attained a masters degree,
The focus group participants appear to closely approximate the national distribution of paramedic faculty who attained an academic degree (graduate degree - 10%, baccalaureate degree - 24%, associate degree - 21%). However, the number of focus group members who reported attending some college (44%) was slightly higher than the 35.5% of paramedic faculty nationally who reported attended some college (Ruple et al., 2005). The program environment of the focus group included representation from 1 four-year public college (11%), 2 community colleges (22%), 4 fire service- or EMS academy-based programs (45%), and 2 career schools (22%). Using the national paramedic faculty data reported by Ruple et al. (2005), the distribution of the focus group program environment closely approximates the distribution of paramedic program environments nationally, which is 26.5% community college-based, 45% fire service- or EMS academy-based, 5% four-year college- or university-based, and 23.5% reporting some other education environment such as private college or career school.

4.6.2 Focus Group Findings

The majority of focus group participants (78%) indicated that they had used the VPE product for one cohort or class of students. The 2 career schools indicated they had used VPE on multiple cohorts or classes. Beta reported using the VPE product with 3 cohorts of students and Gamma reported using the VPE product with 2 cohorts of students. The primary reason for purchasing the VPE product for use in the paramedic program was typically to help students prepare for the NREMT paramedic examination (89%). Only one focus group participant indicated the primary reason for purchasing the
VPE product was to improve the paramedic students’ decision-making ability.

“We purchased the software for our students as a tool to help them better understand how to make appropriate clinical decisions when they finally graduate and become licensed.” (Alpha)

The word coaching was not used anywhere in the final focus group report. Although not used, there were some consistent comments that suggested coaching was made available to students but it was believed to be the student’s responsibility to seek coaching rather than the faculty member’s responsibility to identify the need for coaching. However, it was clear the majority of focus group participants did provide the opportunity inside and outside of class for the students to seek assistance with the case presentations and appropriate patient management.

“We provide each student with a copy of VPE. Each student was instructed to work through each scenario and if they had questions about a specific scenario or patient management protocol, we would make time in class to discuss the case.” (Zeta)

One focus group participant (Beta) indicated she did not use the VPE study guide with her students. She purchased a single copy of the VPE product and utilized just the video and audio portion of the software to provide realism in patient presentations, and then required students to perform the skills on laboratory mannequins while assistant faculty observed student performances, provided feedback, and asked questions to
promote clinical decision making. The focus group member described this in her curriculum as “facilitated-learning stations.” These facilitated-learning stations would appear to include a form of coaching, but do not necessarily follow the standardized unfolding case scenario in the VPE product.

There was an absence of the word scaffolding in the final focus group report. However, one focus group member mentioned the learning triad, described in the implementation manual.

“We used the learning triad that Elsevier mentioned in the implementation manual. Our students were required to complete the textbook readings regarding a particular topic, say trauma or medicine, and attend class lectures as well. At the end of the lectures for the topic, students were assigned the VPE lessons related to those topics as graded homework assignments.” (Alpha)

Another focus group member did not specifically mention the learning triad but did indicate she had her students use the course textbook and VPE study guide in conjunction with the VPE software.

“Our students used the VPE software for self study and practice for the NREMT [paramedic] examination. We told them that they could use their textbook and the [VPE] study guide (with software) to help them with the VPE scenarios.” (Eta)

The final report indicated the majority of focus group participants did not

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systematically implement the learning triad. Rather, they provided the VPE software to
their students as one of many supplements to the learning process and not as an integrated
tool within the curriculum. One focus group member indicated his program would not
use the product again as a part of the initial paramedic education program, but would
instead use it as a component of NREMT reregistration and continuing education
programs because initial paramedic education program students did not have enough
knowledge of disease and injury patterns to effectively use the product.

A trend that arose when analyzing the interview questions related to issues and
barriers to implementation of the VPE product, as well as changes to the VPE product,
was the ease of debriefing for faculty, which ultimately impacted the effect and ease of
remediation. The majority of focus group members (89%), regardless of program
environment, indicated that they expected the current software, or wanted future software
releases, to provide student debriefing in the form of a scoring report. The focus group
members believed that a detailed student debriefing form provided by the software would
be very helpful in targeting remediation. The largest negative comment concerning the
VPE product was the lack of measurement and debriefing provided to the students.
When asked how program faculty used the student performance log provided by the VPE
software to aid in remediation, 78% indicated they did not review student performances
because of education program time constraints.

“We simply do not have time in the program schedule to read the performance log
for every student, and then evaluate where the student made critical decision
mistakes. We had hoped the [software] program would do that for us.” (Iota)
The results of this study appear to be in conflict with the EMS educational model proposed in this study, current literature related to Schön’s reflective practicum, the theoretical rationale presented by Boisot, and the ability of computer-based clinical simulations to enhance experiential learning. There are several observations when integrating the findings of the focus group interviews with the failure to affect student outcomes on the paramedic examination that may help explain this apparent conflict of findings with respect to the current literature and theoretical rationale.

The results of the focus group interviews indicate faculty expected the VPE product to contain sufficient internal pedagogy to assist students with learning and did not require faculty intervention. In addition, there was no indication in the focus group results suggesting an understanding of pedagogies related to coaching, scaffolding, debriefing, or remediation. This may be a reflection of the state of the current paramedic education system, which relies heavily on an objectivist approach to education that narrowly defines the role of the educator as the transmitter of knowledge and the student at the passive recipient of that knowledge. This is evident in the prescriptive lesson plans and curricula that form the pedagogy for current paramedic education (The EMS Education Agenda for the Future, 1996) and the findings of Ruple et al. (2005) that only 22% of paramedic faculty develop their own lesson plans, while 78% use the prescriptive lesson plans provided by the United States Department of Transportation or commercially prepared lesson plans.

Reliance on an objectivist approach to education may have created confusion in student usage of VPE, rendering VPE, a constructionist approach to education, less than
effective. The paramedic student’s educational time is typically characterized by the presentation of knowledge, rules, signs and symptoms, and medical protocols through lectures and textbook readings. There is little time during classroom lectures for students to learn the foundational skills identified by Atkins and Murphy (1993) as necessary for the successful use of reflective thinking by students in the construction of knowledge. Without these skills, students may view the computer-based clinical simulation product through a behaviorist lens, leading them to use the computer-based clinical simulation product as a memory aid to patient management rather than a tool for improving clinical judgment and decision-making ability relative to effective patient management. As Jones (1988, p.33) points out, “If the educators and learners are not in the proper mindset, then their approaches to the learning event will be incompatible with the kind of learning that will be expected of them.”

According to Magee (2006), the educational approach, objectivist or constructivist, establishes the requirements for the use of the simulation. Magee suggests that objectivist simulations are built using a logical, systematic approach where the desire is to present a consistent, standardized message to students across the discipline. This approach works well for positivistic disciplines, such as the military or industrial occupations, where the desire is to create a universally competent workforce or where every person or piece of machinery follows a specific and well-defined function within the system. Constructivist simulations view truth and knowledge as specific to a context or a social construct. Instead of being designed for ensuring a consistent, standardized message, these simulations are designed to allow for a variety of tools and information for guided and facilitated problem-solving scenarios. The current use of products like
VPE, a constructivist-based simulation, in a primarily objectivist educational environment like paramedicine may create ambiguity and chaos within the instructional design, and thus, limit the utility of the simulation educational experience (Magee, 2006).

The lack of improvement in student performance when using the computer-based clinical simulation product may be, in part, an outcome of the academic preparation of paramedic faculty. It is estimated that less than 24% of all paramedic faculty have attained formal education to the level of a baccalaureate degree and slightly more than 35% have only attended college without attaining a terminal degree (Ruple et al., 2005). The VPE product assumes faculty were an integral component of the success of computer-based clinical simulations through the implementation of pedagogies that promote coaching, scaffolding, debriefing, and remediation. This presupposes faculty members have been academically prepared to implement these pedagogies, which does not appear highly probable, based on the results reported by Ruple et al. (2005).

Regardless of their academic preparation, it is clear that faculty believed the computer-based simulation product was an all-inclusive educational tool and did not require their intervention for success. This resulted in little or no integration of the computer-based clinical simulations across the curriculum, effectively eliminating scaffolding as a useful pedagogy.

Whether related to academic preparation or paramedic education program time constraints, as suggested by analysis of the focus group results, it is apparent that effective debriefing and feedback on student performance was not a typical action by faculty members. Several researchers in education, social science, and nursing have identified debriefing and feedback as a teaching strategy that is essential to the learning
experience, particularly when it is used as a part of clinical simulations (Cantrell, 2008; Babenko-Mould, Andruussyzyn, and Goldberg, 2004; Horsfall, 1990; Matthews and Viens, 1988). Debriefing and feedback, following completion of a patient scenario, whether through individual/faculty discourse or through class/faculty discourse, gives the student the opportunity to discuss what they have learned, process what they have learned, identify alternative hypotheses for patient care, and practice reflective and critical thinking. Failure to use debriefing and feedback pedagogy with computer-based clinical simulations may hinder the experiential learning process that forms the foundational theory directing the development of the VPE clinical simulation product, as well as causing tension between the product and the preferential learning style of the paramedic student.

4.7 Summary

The major findings reported in this chapter can be summarized as follows:

1. VPE usage had no overall effect on the EMT examination and the paramedic examination.

2. Service type had an overall effect on the EMT examination and the paramedic examination.

3. Gender had an overall effect on the EMT examination and the paramedic examination.

4. The interaction between VPE usage and service type had no overall effect on the EMT examination and the paramedic examination.

5. The interaction between VPE usage and gender had no overall effect on the EMT examination and the paramedic examination.
6. The interaction between service type and gender had no overall effect on the EMT examination and the paramedic examination.

7. The interaction between VPE usage, service type, and gender had no overall effect on the EMT examination and the paramedic examination.

8. Paramedic faculty revealed little, if any, integration of the VPE product across the traditional paramedic curriculum. The majority of faculty used the software as a supplement to the curriculum in the form of a self-study tool for the student. Paramedic faculty, in general, did not implement pedagogy related to the concepts coaching, scaffolding, debriefing and remediation with respect to the implementation of the computer-based clinical simulation software.
Chapter 5: Conclusions

5.1 Summary of Research Design and Major Findings

This research investigated the effect of using computer-based clinical simulations to improve paramedic student outcomes when attempting the paramedic examination. The sample in this research comprised 5966 paramedic students who attempted the paramedic examination between the inclusive dates of July 1, 2007 and June 30, 2008. Paramedic outcome and demographic data were provided by the National Registry of Emergency Medical Technicians (NREMT), while the Virtual Patient Encounters (VPE) usage data and end-user focus group interview data were provided by the VPE producer, Elsevier Inc.

The dependent variable was recorded as the student score achieved when taking the first attempt of the paramedic examination. The covariate was recorded as the score the student achieved when taking the emergency medical technician (EMT) examination. Both the paramedic examination and the EMT examination demonstrated acceptable reliability and validity. There was a statistically significant linear relationship between the paramedic examination and the EMT examination. However, analysis of collinearity did not reveal the presence of high multicollinearity.

The independent variables were VPE usage, service type, and gender. Elsevier Inc. provided the students’ VPE usage classification based on sales records of the VPE product during the inclusive dates of the study. Students were assigned to service type
and gender based on data provided by the NREMT, which reflects the answers each student provided on the application to attempt the paramedic examination.

The current study used a 2 by 2 by 2 completely crossed, unbalanced factorial design, featuring 2 levels of usage (use and non-use) of Elsevier’s Virtual Patient Encounters (VPE), 2 levels of gender (male and female), and 2 levels of work environment (fire-based and non–fire-based). The dependent variable was the student score on the paramedic examination, while the covariate was the student score on the EMT examination. Analysis of Covariance (ANCOVA) and a review of the focus group findings of paramedic faculty using the VPE product during the inclusive dates of the study were conducted. The purpose of the review of the focus group findings was to determine if coaching, scaffolding, debriefing, and remediation pedagogies were utilized in conjunction with implementation of the VPE product.

Major findings of the quantitative analysis of this study included the absence of a significant multivariate effect of VPE usage on student examination performance. ANCOVA analysis revealed a significant main effect for both service type and gender on the paramedic examination after controlling for variance attributable to the EMT examination. Study participants indicating service type as fire-based tended to achieve higher scores on the paramedic examination, after controlling for scores achieved on the EMT examination, than do those study participants indicating service type as non–fire-based. Likewise, males tended to achieve higher scores on the paramedic examination than did females, after controlling for scores achieved on the EMT examination. However, in both variables, service type and gender, the effect size was very small suggesting little practical significance to these findings. The ANVOCA did not reveal
any significant three-way or two-way interaction effects related to VPE usage, service
type, or gender on the paramedic examination after controlling for scores achieved on the
EMT examination.

The qualitative analysis of this study revealed little, if any, pedagogical changes
were made by paramedic faculty when implementing the VPE product within the
paramedic education program. The majority of faculty indicated that VPE software was
provided to students as a supplement and not integrated into the curriculum; therefore,
scaffolding from the textbook and lecture was not considered. In addition, while students
appeared to be provided the VPE study guide, there was very little, if any, coaching
provided to the students. With respect to debriefing and remediation, the faculty
indicated paramedic education program time constraints made this difficult and expected
the VPE software to provide these elements to the student without faculty assistance.

The quantitative findings were unexpected, as the use of reflective thinking has
been demonstrated to successfully improve clinical decision making and problem solving
in both nursing and medicine (Gokhale, 1991; Quinn, 1991; Lowe and Kerr, 1998; Davis
et al., 1999; Heinich, 1999; Leemkuil, 2003; Medley and Horne, 2005). While
statistically nonsignificant, the analysis of variance findings, when combined with the
qualitative findings, provide important practical information that may help with future
studies related to use of simulation technology within the paramedic education
environment. The lack of improvement in student examination scores is disappointing;
however, it is clear that the use of VPE software did not degrade student performance.
This is an important finding when combined with the evidence that faculty failed to
implement the computer-based clinical simulation product as recommended by the
developer and failed to utilize the pedagogies necessary for success. This suggests that the use of computer-based clinical simulations may indeed improve student performance, if students are provided with the necessary tools and education to effectively use reflective thinking and faculty use the necessary pedagogies related to technology-based education.

5.2 Implications

While the current research related to the use of computer-based clinical simulations appears to not support the improvement of paramedic student success on the paramedic examination, it should not be inferred that these findings are in conflict with the theoretical concepts of experiential learning and problem-based learning, and the educational model for EMS. As pointed out by Atkins and Murphy (1993), student foundational skills related to reflective thinking, such as communicating a comprehensive account of the computer simulation experience, the ability to identify existing knowledge, ability to explore alternative patient management strategies, and ability to evaluate patient care outcomes are critical to the educational success of using computer-based clinical simulations. Similarly, Heinich et al. (1999) reported that without implementation of appropriate pedagogy by faculty, the student will gain little from the use of clinical simulations.

When the quantitative results are viewed in conjunction with the qualitative results, it appears that the lack of improvement in student success may be more a function of appropriate use of the computer-based clinical simulation product by paramedic faculty, student’s prior acquisition of reflective thinking skills, and the level of
preparation of faculty to implement the necessary pedagogy related to coaching, scaffolding, debriefing, and remediation within the realm of computer-based clinical simulation education. As the EMS education system begins to embrace technology-based learning tools, paramedic faculty must familiarize themselves with the appropriate pedagogical approaches to the use of simulations. EMS educators should begin to view simulation-based education as more than just the use of computer software or adding a mannequin to a skills lab. Rather, they should view simulation education as a combination of simulation technology, faculty preparation in the appropriate use of the technology to maximize educational advantage, curriculum integration, and student reflective thinking ability.

Currently, each state determines the rules and regulations for permitting an individual to be designated a state-approved paramedic educator. This usually requires evidence of clinical experience and completion of an instructor education program developed by the lead state EMS agency. These instructor education programs typically mimic the behavioral model of knowledge transmission that is consistent with the paramedic education program. The findings of this research suggest that these state instructor education programs may need revision to include academic preparation in the use of pedagogies that enhance simulation technologies, such as pedagogies that improve reflective thinking skills of students. An alternative to amending these state instructor education programs may be collaboration with postsecondary schools of education to provide terminal degree opportunities for potential paramedic faculty. Consideration of education philosophy, theory, and pedagogy are required to ensure paramedic faculty members enhance students’ reflective thinking skills and maximize the potential benefit
of computer-based clinical simulations. Regardless of educational approach, if the EMS education system is going to embrace technology-based learning, the state instructor certification rules may need to be amended to include a preservice education requirement in the use of these technologies and pedagogies.

The focus group results appear to indicate a lack of understanding by the product developer of the characteristics and demographics of the EMS education system, as evidenced by the faculties’ complaints of paramedic education program time constraints related to reading and analyzing student performance logs. Future development of technology-based products specific to the EMS educational community should include a comprehensive needs assessment focusing on both faculty and student needs. It is unfortunate that the current research did not included student interviews and student focus group activities. Currently, technology developers use simulation and curriculum design experts when developing the clinical simulation products for the classroom. When one considered that interaction with the final product is primarily with students, secondarily with faculty, and seldom with the simulation or curriculum experts, it is necessary that future development of education technology must begin to incorporate both faculty and student input early in the design phase. This would assist the developer to simultaneously include tools within the final product that would assist faculty with pedagogical issues and time constraint issues while providing students with activities and tools necessary for improving reflective thinking skills necessary for success when immersed in clinical simulation technology.

While not directly impacting the effect of VPE usage on student outcome performance, the disparity in student outcomes related to service type and gender should
be addressed. The paramedic examination should be assessed for evidence of differential item functioning related to service type and gender in an attempt to reduce or eliminate any untoward impact of these items on the success of students. In addition, faculty should be aware of the potential for these disparities and proactively monitor student performance to identify motivation issues, as well as weaknesses in mathematics and science so that appropriate pedagogies can be implemented to reduce negative impact on student performance.

5.3 Future Research

The current research used ANCOVA for statistical analysis. It is recommended that future designs should consider using log-linear analysis. Log-linear models are special cases of general linear models that allow for better analysis of dichotomous and categorical variables. Log-linear analysis analyzes association between grouped data, and much like ANCOVA and ANOVA, looks at all main and interaction effects in order to find the simplest model that accounts for cell frequencies in the factorial design.

Most variable length CAT examinations, like the NREMT examination or those administered for the purpose of issuing certification or licensure within public safety, are administered to determine an \textit{a priori} ability level necessary for safe practice. These examinations are not typically designed to determine a test taker’s precise ability level or rank order performance of a group of test takers. This combination of variable length CAT examination and pass/fail decision rule results in a ceiling effect relative to the score distribution. Because the examination is terminated once an test taker’s score is determined to be above the \textit{a priori} ability level, scores are systematically refrained from
approaching the maximum value of the logit scale. The use of a dependent variable obtained from the outcome of a variable length CAT results in reduced variance in the score distribution because of the nature decision rules for pass/fail of the examination. Use of log-linear analysis will negate the problem of reduced variance by converting the examination score to a categorical variable.

Reanalysis of the data in the current study using a log-linear model is also recommended. The independent variables (VPE, service type, and gender) are already reported as categorical data, so no data transformation is needed. However, both the EMT examination score and the paramedic examination score are interval data and must be transformed into categorical data before beginning the analysis. The EMT score can be transformed into the following three logical categories: 1 = scores 70 through 79, 2 = scores 80 through 89, and 3 = 90 through 100. The paramedic score can be transformed into the following two categories: 1 = passing score, 2 = failing score. Transforming the paramedic score in this manner will negate the reduced variance and provide additional power to determine the effect of the other variables on the pass/fail outcome of the paramedic students. If the researcher is interested in determining the effect of the other variables on student ability regardless of pass/fail status, a different transformation of the paramedic score is recommended. In this case, the paramedic score should be transformed into the ability bands that were used to sculpt the CAT examination. Using this transformation, the research could determine the effects of the other variables on the paramedic student’s improvement from a lower ability level to a higher ability level, regardless of pass/fail status.

The causal comparative nature of the current research prevents any statements
related to causation. Future research in this arena should include a true experimental design using Astin’s (1991) input-environment-outcome model for evaluation. The underlying premise of Astin’s evaluation model is that educational assessments should provide some level of understanding about the causal link between educational practice and educational outcomes. According to Astin (1993), the key to success in using this model is to minimize error associated in causal inferences. One method of minimizing error is to control input characteristics at the beginning of the learning experience. This should result in reduced bias and inaccuracies related to estimates of environmental effects on educational outcomes. A few of the characteristics that are important to investigate in future research related to paramedic education and simulation technology are race/ethnicity, academic preparation of faculty, type of academic institution, academic preparation of students, peer group influence, and the educational culture of the academic institution and the state education system.

Race has been shown to play a major role in the life of a student (Battle and Lewis, 2002; Tam and Bassett Jr., 2004). Indeed, a study conducted by Dickison et al. (2006), confirmed an effect of race on paramedic examination scores. However, research on race and the impact of simulation technology is scarce. Future research related to the use of clinical simulation within the paramedic education domain should include student race as a variable. This research should not focus merely on replicating previous research of race disparity related to standardized or high-stakes examinations; rather, it should include a design to investigate interactions between race and simulation usage, while controlling for the variance of examination scores related to race alone. These designs would allow researchers to identify race effects related to simulations and provide
direction for additional research by simulation technology developers and education experts focusing on simulation and pedagogical designs which would ameliorate any disparate effect of technology based education related to race.

A student’s education outcome and academic success is greatly influenced by the type of school that they attend (Crosnoe, Johnson, and Elder, 2004). School factors include school academic policies, composition of the faculty, and overall school climate. The school one attends is the institutional environment that sets the parameters of a student’s learning experience (Pascarella and Terenzini, 2005). Previous research related to paramedic and EMT education suggests an association between student success on EMS credentialing examinations and faculty characteristics (Russ-Eft, Dickison, and Levine, 2005), quality of educational material (Russ-Eft et al., 2005), and academic institutions (Dickison et al, 2006). These researchers reported that students graduating from paramedic programs taught in institutions of higher learning tended to perform better with respect to the credentialing examination than their counterparts who received education within the public safety academies and hospital settings. These findings suggest future research related to clinical simulation technology should view both students and faculty as nested within academic institutions. This effect of nesting should not be overlooked in future research designs. Investigating differences in faculty and student characteristics nested within academic settings may provide powerful information related to best practices of faculty and students as they interaction with simulation technology.

In addition, it is very important that future research consider academic preparation of faculty when analyzing and interpreting data. The current paramedic
education system continues to embrace the concept of a great paramedic clinician equates to a great paramedic educator. The belief of “see one, do one, teach one” is still a driving force behind the selection of many paramedic faculty within the EMS education system. Prior research conducted by Margolis and Dickison (2005) indicated paramedic students whose faculty were nurses performed better on the paramedic examination than all non-nurse faculty. In addition, there was a significant positive linear relationship between the educational degree of the faculty member and student performance on the examination. The researchers showed that as the educational degree of the faculty increased from associate degree to doctoral degree, student performance on the paramedic examination increased in a linear fashion. These findings suggest that nesting of faculty within the academic institution may also impact the effect of clinical simulation technology on student education performance.

Foundational academic preparation of students has been correlated to future success of students in postsecondary education (Pascarella and Terenzini, 2005). Research related to student characteristics that predict success on the paramedic examination revealed high school class rank and years of education prior to entering the paramedic program were positive predictors of success (Fernandez et al, 2008; Dickison et al, 2006). Dickison (2006) reported a nearly linear relationship between number of years of education and improved success related to the paramedic examination. Of particular importance to future research is the finding that paramedic students whose highest level of education was a general education diploma (GED) were highly unlikely to be successful when attempting the paramedic examination, those completing 4 years of high school were only slightly more likely to be successful, and those attending some college were
significantly more likely to be successful. Future research related to the use of technology within paramedic education should include some measurement of students’ prior academic preparation. Of particular importance is a measure of the student’s ability to utilize the skills necessary for reflective thinking such as: (1) ability to examine how a situation has affected the student and how the student affected the situation; (2) ability of the student to communicate a comprehensive account of the experience; (3) ability of the student to synthesize and integrate information; (4) ability of the student to identify existing knowledge, challenge assumptions, and explore alternatives; and (5) ability of the student to evaluate his or her new perspective (Atkins and Murphy, 1993).

Peer groups are an important socialization agent (Pascarella and Terenzini, 2005). Higher degrees of peer pressure and the degree to which students adopt values and beliefs that are sanctioned by their peer groups have been shown to impact academic performance (Pascarella and Terenzini, 2005). While not included in the current study, effects of peer pressure appear to have merit for inclusion in future studies. Some of the positive effect of VPE, related to the fire-based paramedic, may be related not only to extrinsic factors such as salary and work environment, but may also be related to peer pressure exerted by being a part of the firefighter “family.” The tight “family” bond that exists with the fire service culture is not as readily identifiable in the non–fire-based culture. The fire culture of helping “my brother” may be a variable that helps improve the success of fire-based paramedic students as they matriculate through the education program and may require further investigation.

Another area of interest in future research focused on the use of simulation technology to improve paramedic education is the EMS education culture of the state.
There is significant variation in the overall paramedic examination pass rate among the states. Pass rates range from less than 50% to greater than 90%. This wide range of success rates by state jurisdiction suggests significant differences in educational culture. An understanding of these differences and their impact on students’ foundational academic preparation, as well as the impact of the educational culture on the effort the student applies toward learning, is necessary to help interpret data of future studies focused on simulation technology. Carbonaro (2005) identified three types of student effort that are impacted by school culture: (1) rule-oriented effort, (2) procedural effort, and (3) intellectual effort. Academic cultures that promote role-oriented effort typically focus on behavioral (affective) characteristics, such as abiding by classroom rules and respecting fellow classmates. Procedural effort is typically seen in academic institutions with clearly defined demands, such as completing assignments. Academic institutions that promote intellectual effort tend to focus on activities that promote critical thinking and knowledge construction related to the program of study. Future research should consider which educational culture is the predominant culture supported by the state EMS education system. It is reasonable to assume an educational culture that promotes rule-oriented or procedural effort will impact the use of simulation technology differently than a culture that promotes intellectual effort.

Future studies should be designed to determine the effectiveness of the implementation of simulation technology within EMS education. The research design should include cohort random sampling to ensure representativeness of program and faculty characteristics. Research using factorial designs should carefully consider the potential effect of nesting students within faculty and faculty within academic
institutions. Within each selected program, faculty should receive pretraining on the effective use of pedagogies related to clinical simulations. Students should be randomly assigned to clinical and nonclinical simulation groups prior to the beginning of the study. Outcome measures should include both the paramedic [written] examination and the paramedic skills-based examination. Individual focus group interviews of faculty and students should be conducted to understand how input variables related to students and faculty impact the learning experience, educational environment, and faculty teaching experience.

In addition, in using a true experimental design to duplicate this study, there are other lines of inquiry focused on simulations within education that may be beneficial. Specifically, research into the theory underlying knowledge creation in simulation environments is recommended. Current research related to educational simulations is typically founded on the theoretical perspectives associated with global multimedia instructional design. Given the lack of theoretical perspectives related to pedagogical models of education simulation, research related to understanding the theories that underlie simulation education design may provide insight into reasons for success and failure of the simulation experience.

Another area of research that requires investigation is the educator’s belief system with respect to educational simulations. According to Magee (2006), many studies have identified teachers’ attitudes and confusions about simulation as an issue in the successful use of clinical simulations. Most of these studies identified a conflict between the educational environment and the clinical simulation being used. In addition, most current research suggests that a solution to this conflict is the creation of professional
development courses for educators, focused on the understanding of technology-based pedagogies that provide for effective teaching with simulations (Magee, 2006).
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Appendix A: Sample NREMT Style Examination Items

1. You place an oral airway in a patient and notice a fruity odor on the patient's breath. You ask the police to search the home for any clues which could help you confirm your suspicions. You should inform the police to first check
   a. under the kitchen sink. (0)
   b. in the patient's bedroom. (0)
   c. inside the refrigerator. (2)
   d. in the patient's medicine cabinet. (0)

2. Your patient has lost an estimated 300-350 mL of blood immediately after delivery and continues to have a bloody discharge while enroute to the hospital. Your action in this situation should be to
   a. call medical control and set up a pitocin drip. (0)
   b. increase the rate of IV infusion and place PASG on the patient. (0)
   c. continue to monitor the blood loss and keep perineal pads in place. (2)
   d. place the infant on the mother's breast and start an IV to run wide open. (1)

3. You place an oral airway in an unresponsive patient and notice a fruity odor on the patient's breath. Your assessment reveals rapid and deep respirations, hot dry skin and a decrease in systolic blood pressure. Based upon the history and assessment findings, your impression is the patient has
   a. diabetic ketoacidosis. (2)
   b. cerebrovascular insult. (0)
   c. myocardial infarction. (0)
   d. hyperosmolar non-ketotic coma. (0)

4. A 56 year old male with a history of mental illness and depression suddenly has a change in behavior. His family reported that during the past few days he "seemed normal." He is now upstairs in his home and his family thinks he may have a gun. You should suspect this patient is
   a. planning a homicide. (2)
   b. upset with his family. (0)
   c. considering suicide. (0)
   d. paranoid. (0)
5. You find a 42 year old male who has experienced a syncopal episode and chest pain while golfing and is now complaining of dizziness and nausea. His blood pressure is 76/40. The cardiac monitor displays sinus tachycardia. After administering oxygen and a fluid challenge, the vital signs remain the same. Your next treatment for this patient should be to consider administration of

a. verapamil 5.0 mg IV push. (0)
b. adenosine 6.0 mg IV push. (1)
c. lidocaine 1.5 mg/kg IV push. (0)
d. dopamine titrated to an acceptable blood pressure. (2)

6. During your assessment of a patient, the paramedic finds cold, clammy skin and delayed capillary refill. The patient responds appropriately to questions but answers in whispers. His vitals are BP 90/80, P 124, R 24. From the information obtained up to this time, you can best determine the severity of his hypotension by the

a. mechanism of injury. (0)
b. narrowed pulse pressure. (2)
c. delayed capillary refill. (1)
d. amount of blood on the scene. (0)

7. A 56 year old male with a history of mental illness and depression suddenly has a change in behavior. His family reported that during the past few days he "seemed normal." He is now upstairs in his home and his family thinks he may have a gun. In managing this situation, your most appropriate next step should be to

a. contact your dispatcher and request police assistance. (2)
b. send a family member upstairs to reason with him. (0)
c. go upstairs to physically restrain the patient. (0)
d. immediately leave the scene in your ambulance. (0)
8. You arrive at a home where the police let you in. You find a 46 year old male who is unconscious. His neighbor reports he told him yesterday that he had "a bad case of the flu." When the neighbor tried to call him no one answered the phone. The concerned neighbor called the police who dispatched your ambulance. The patient is lying on the sofa. He is warm to touch with poor skin turgor. His vitals signs are BP 110/82, P 132, R 26 and labored. Based upon the above signs and symptoms, you should begin your questioning of the neighbor by asking

a. if the patient complained of any acute problems. (1)
b. where the patient works. (0)
c. how long the patient was unconscious. (1)
d. if the patient has a history of any known diseases. (2)

9. Initial arterial blood gas analysis on a patient who is intubated reveals a PaCO₂ of 55 mmHg, PaO₂ of 300 mmHg, and a pH of 7.24. This condition is known as

a. respiratory alkalosis. (1)
b. metabolic acidosis. (1)
c. respiratory acidosis. (2)
d. metabolic alkalosis. (1)

10. You respond to a construction site and find a worker entrapped by a load of steel pipes that had fallen on him. Although the scene is secure, rescuers are still working to free the victim's legs. During your limited initial assessment, you find the 34 year old responding only to painful stimuli by groaning. There is discoloration and distention of the abdomen about the RUQ and you observe a dilated left pupil that does not respond to light. Vital signs are BP 82 by palpation; P 124 and weak; and R 20, shallow and irregular. Oxygen should initially be administered to this patient via

a. bag-valve-mask with supplemental oxygen at a rate of 20-24 ventilations/min. (2)
b. non-rebreathing mask with reservoir at 10-15 L/min. (0)
c. demand valve and mask at a rate of 12-16/min. (1)
d. simple face mask at 10-12 L/min. (0)
Appendix B: Example of the Gross Modification of the Nedelsky Formula

Using the items listed in Appendix A and the modified Nedelsky formula (Gross, 1985) listed on page 59, where the weight of the correct response is equal to 2, sophisticated options are equal to 1, non-sophisticated options are equal to 0, and k is set equal to 5, the multiple passing index for each item would be calculated as follows:

1. \[\frac{2}{(0+0+0+2)} - \frac{1}{5}(0+0+0+2) = .90\]
2. \[\frac{2}{(1+0+2+0)} - \frac{1}{5}(1+0+2+0) = .60\]
3. \[\frac{2}{(2+0+0+0)} - \frac{1}{5}(2+0+0+0) = .90\]
4. \[\frac{2}{(0+0+0+2)} - \frac{1}{5}(0+0+0+2) = .90\]
5. \[\frac{2}{(0+0+2+1)} - \frac{1}{5}(0+0+2+1) = .60\]
6. \[\frac{2}{(0+0+2+1)} - \frac{1}{5}(0+0+2+1) = .60\]
7. \[\frac{2}{(0+0+0+2)} - \frac{1}{5}(0+0+0+2) = .90\]
8. \[\frac{2}{(0+1+2+1)} - \frac{1}{5}(0+1+2+1) = .45\]
9. \[\frac{2}{(1+1+1+2)} - \frac{1}{5}(1+1+1+2) = .36\]
10. \[\frac{2}{(1+2+0+0)} - \frac{1}{5}(1+2+0+0) = .60\]

The raw cut score for a test using this method is determined by summing the individual multiple passing indices. In this example, the sum of the multiple passing indices is 6.81, which represents the raw score necessary to meet the minimum passing standard.