CONSTRUCTION OF 3D CARDIOPULMONARY RESUSCITATION EMERGENCY SCENARIOS FOR FIRST RESPONDER PRE-NURSING TRAINING ON STEREOSCOPIC DISPLAY SYSTEMS

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INTERDISCIPLINARY ENGINEERING

ABSTRACT

In today’s society there is a need to have well prepared medical staff, especially in cases of cardiac arrest, and nurses are one of the first lines of defenses against cardiac arrest. They play a crucial role as first responders to administer cardiopulmonary resuscitation (CPR) to patients in need of resuscitation, but CPR history has demonstrated CPR as a difficult process to learn for both medical professionals and laypersons. There are consistent recurring changes in guidelines to improve CPR practice which may promote changes within CPR knowledge, and the administration of CPR may also differ in complexity depending on the patient or victims current condition. Additionally CPR performance has a pivotal role in the chain of survival, but throughout its history there have been repeated studies that suggest poor performance and retention among CPR certified and uncertified individuals from bystanders to medical professionals. As a means to promote improvement in the retention of CPR performance and knowledge, technology has been implemented into various CPR training studies, and has shown positive results when applied during CPR training. The key objective of this research study is applied by using virtual reality, and evaluating the effect of this technology during a mixed reality simulation on knowledge, performance, and attitude. A mixed
reality environment was developed to place pre-nursing students in simulated virtual environments with and without distractions as a reinforcement tool for CPR training. This study was used to demonstrate the use of mixed reality training as a supplemental tool to improve the retention of knowledge, performance, and to evaluate the attitude of pre-nursing students during CPR training. Subsequently it also assisted in the further understanding of virtual reality, and its effects on users. Attitude evaluations were also completed to assess the students’ response to the mixed reality environment training for the intervention or treatment group.

**Keywords:** CPR, CPR Training, Virtual Reality, First Responder, Pre-Nursing, Mixed Reality Simulation
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CHAPTER 1
INTRODUCTION

The early initiation of first responder medical treatment is critical for increasing the likelihood of survival for victims in an emergency, especially in the case of resuscitation (Hunziker, et al., 2011). Approximately for every delayed minute of treatment, the victim’s chances of survival decreases drastically as much as 10% per minute depending on the circumstance (Hunziker, et al., 2011; Ertl & Christ, 2007). This is a factor that makes first responder training and preparedness important (Hunziker, et al., 2011). First responders are composed of multiple disciplines with varying expertise; therefore first responder training must adhere to specific guidelines to ensure readiness.

Responders receive many levels of first aid training including the use of cardiopulmonary resuscitation (CPR) which is a critical component in determining survival of a victim in cardiac arrest. However, CPR training has been proven to have both poor retention and performance ratings (Christenson, et al., 2007).

Cardiac arrest contributed to approximately 490,000 deaths second to only cancer within the United States in 2006 (Kellum, Kennedy, & Ewy, 2006). An estimated 220,000 cases per year of cardiac arrest occur within the United States alone, and many of these cases are out-of-hospital developments witnessed by bystanders or lay persons (Christenson, et al., 2007). Those 220,000 cases have steadily increased to over 300,000 out-of-hospital cardiac arrest cases within a 5 year time span within the United States.
Due to the nature of spontaneous occurrences of cardiac arrest there is a need to have properly trained individuals as a response (Celenza, et al., 2002), and this has led to multiple establishments providing varying CPR training practices. As a result individuals acquire different skill sets for the same procedure. This may lead to improper training or a reduction of CPR knowledge during course training (Parnell & Larsen, 2007). It has been reported that medical professionals' and bystanders' CPR knowledge and performance begins to degrade immediately after completing the certification course in most cases from 80% to 47% after a 12 month period (Christenson, et al., 2007; Ertl & Christ, 2007; Mahony, Griffiths, Larsen, & Powell, 2008; Parnell & Larsen, 2007). Even after attending a refresher course trainees may perform inadequately when executing the CPR procedure in a resuscitation attempt. Poor performance measurements observed nearly a decade ago are still evident in steps such as opening of the airway, rescue breaths, chest compressions, and many other steps during the CPR process (Hunziker, et al., 2011; Woollard, et al., 2004). Therefore efficient and effective training has always been an issue for CPR (Hostler, Rittenberger, Roth, & Callaway, 2007; (Yost, et al., 2012; Bolus, 2011). This implies that there is a need to try more alternative approaches to the teaching practices of CPR. Some of these alternatives involve the use of technology and self-learning to boost the retention, confidence, and performance levels of CPR trainees (Arntz, 2011; Christenson, et al., 2007; Ertl & Christ, 2007; Hunziker, et al., 2011; Lynch, et al., 2005).
The CPR procedure is among the first steps in solidifying the chain of survival, and guideline updates occur approximately every 5 years to improve productivity in trainees. Organizations around the world such as International Liaison Committee on Resuscitation (ILCOR), the American Heart Association (AHA), the Heart and Stroke Foundation of Canada (HSFC), the Australian and New Zealand Committee on Resuscitation (ANZCOR), the Resuscitation Council of Southern Africa (RCSA), the Inter-American Heart Foundation (IAHF), the Resuscitation Council of Asia, and participating partners assist in defining these guidelines (Nolan, et al., 2010). These new improvements found through various research strategies have brought changes in compression and ventilation rates, defibrillation, and other methods that affect the administration of traditional CPR techniques (Ewy & Sanders, Alternative approach to improving survival of patients with out-of-hospital primary cardiac arrest, 2012; Nolan, et al., 2010).

A recent advancement has been in the form of continuous quality improvement (CQI), to assist in the delivery of a system of resuscitation guidelines and training employed by Gordon Ewy and Arthur Sanders. This method was used to address the public health problems by identifying a baseline measurement, implementing changes, and measuring the outcomes. The CQI process is used to optimize performance by continuously redefining guidelines, instructions, or training through reevaluations until a desired result or optimal performance is achieved. This approach’s introduction and implementation first occurred in Tucson in rural Wisconsin, and primarily used later by emergency medical services (EMS) in Arizona for out-of-hospital cardiac arrest incidents.
Another major advancement made at the University of Arizona by the Sarver Heart Center Resuscitation Group introduced cardiocerebral resuscitation to significantly improve neurological survival (Ewy & Kern, Recent advances in cardiopulmonary resuscitation, 2009). This method has 3 main components that are continuous chest compressions (CCC) for bystander resuscitation, new emergency medical services (EMS) advanced life support (ACLS) algorithm, and aggressive post-resuscitation care including hypothermia and early catheterization/intervention. It has led to major guideline changes from its initial introduction in Arizona in 2003 to its AHA recognition in the 2005 updated guidelines due to its ability to provide uninterrupted compressions, and being more appealing to bystanders that may witness out-of-hospital cardiac arrest (Ewy & Kern, Recent advances in cardiopulmonary resuscitation, 2009). Other studies have experienced similar acceptance among bystanders as well as medical professionals when comparing the willingness to perform CCC CPR compared to traditional mouth to mouth CPR (Cho, et al., 2010; Hamasu, et al., 2009). Studies such as these are usually reviewed and considered by experts to determine country or worldwide guidelines in resuscitation to better communicate and reduce the complexities of CPR. Other improvements to CPR consider a more modernized solution which will be discussed in a later section of the paper.

Guidelines can be difficult to follow in some situations, and any plan of the nature of one size fits all for guidelines in resuscitation does not exist, especially in the case of out-of-hospital cardiac arrest. Variable rates have been shown over the previous
guideline introduction in 2005 with survival rates increasing as much as five times in the case of ventricular fibrillation median survival varied from 7.7% to 39.9% (Ewy & Sanders, Alternative approach to improving survival of patients with out-of-hospital primary cardiac arrest, 2012). These results only assist in showing the complexity of designing guidelines that could possibly improve everyone’s chances of survival not only locally but globally as well. These guidelines have a direct impact on the training of individuals during CPR courses. Three primary factors that have prompted these important studies and guideline changes in resuscitation are related to the issues of cardiac arrest, the complexity of developing well communicated CPR programs to improve victims’ chances of survival in cases of sudden cardiac arrest, and attitudes towards CPR practices.

**Cardiac Arrest**

When cardiac arrest occurs there may be a failure of the heart which may lead to ineffective contracting of the muscle or no contracting limiting or stopping the flow of oxygenated blood from reaching other parts of the body. There can be many reasons why a person may experience cardiac arrest such as disease, injury, age, weight, or poor health. A typical reason in the United States and in other countries is cardiovascular disease, or other influencing factors that could cause sudden cardiac arrest (McNally, et al., 2011). In one study, the author states that survival in out-of-hospital cardiac arrest cases is a major concern for any community, and improvements have been poor (Iwami, et al., 2006). Ewy describes cardiac arrest as being a major public health issue for the United States for decades with an estimated 300,000 cases occurring out of the hospital environment. After the age of 40 male residences in the United States have a 1 in 8
chance of dying from cardiac arrest, and typically the first sign of cardiovascular disease holds a high probability to be the last sign. Even with guideline changes over the period of 1974 to 2008 the survival rates for out-of-hospital cardiac arrest in the United States remained unchanged with an average of 7.6% over a 30 year period (Ewy & Sanders, Alternative approach to improving survival of patients with out-of-hospital primary cardiac arrest, 2012). Additionally out-of-hospital cardiac arrest pertaining to ventricular fibrillation has shown a survival rate average of 17.7% which has remained unchanged for a 23 year period; while cases in Europe have also shown an average of 21% that was unchanged from 1980 to 2004 (Ewy & Sanders, Alternative approach to improving survival of patients with out-of-hospital primary cardiac arrest, 2012). Nakamura et al. has also conducted studies in out-of-hospital cardiac arrest in relation to reducing the mortality rates and what actually causes the decrease in cardiac arrest associated deaths. He concluded that his model suggested that improvements in out-of-hospital cardiac arrest survival were directly related to out-of-hospital care with early defibrillator shocks which constituted to a decline in cardiac arrest mortality rates in Osaka, Japan (Nakamura, et al., 2012). However a study conducted by Tomohiko Sakai et al. indicated some ventricular fibrillation (VF) during cardiac arrest may be shock resistant, and that further efforts were needed to reduce the mortality rates of shock resistant VF (Sakai, et al., 2010). Many countries throughout the world are faced with the same issue of cardiac arrest, and resuscitation guidelines and CPR performance are the front lines of defense. Narkamura demonstrates in his study that improved out-of-hospital care, CPR, and defibrillator usage can assist bystanders in sustaining life (2012).
CPR PROCEDURE

CPR is considered the front line of defense against cardiac arrest, but it is a process that can become a daunting task even in simple practice. Additionally the added pressures of knowing that someone’s life is potentially in the responder’s hands can complicate matters exponentially if he/she is not physically and mentally prepared for a life threatening situation (Moran & Stanley, 2011; Tanigawa, Iwami, Nishiyama, Nonogi, & Kawamura, 2011). Two issues that can affect CPR performance are the variety of procedures and sequences of CPR that lead most people into believing that CPR is a very complicated process (Kuramoto, et al., 2008; Perkins, et al., 2008). The CPR process mainly involves chest compression and ventilation, but there are other factors such as checking responsiveness, recognizing cardiac arrest, activating the EMS, checking the victim’s pulse, defibrillation, the victim’s initial condition, etc. that quickly complicates the process (Hazinski & Hunter-Wilson, 2011; Perkins, et al., 2008). These procedures are generally categorized into processes related to adult, child, and infant CPR.

Before each procedure is discussed in detail an important guideline change has taken place indicating a switch from the previous standard of Airway-Breathing-Chest Compression (A-B-C) to Chest Compression-Airway-Breathing (C-A-B) in the AHA 2010 guidelines, and this change requires the reeducation of everyone who has ever learned CPR (Hazinski & Hunter-Wilson, 2011). This change was proposed by the authors and experts that assisted in the creation of both the AHA 2010 Guidelines for CPR and the Emergency Cardiovascular Care (ECC) to increase survival outcomes (Moran & Stanley, 2011). Other standards have also been demoted on the priority list such as the concept of look, listen, and feel with more emphasis being placed on artificial
blood circulation through chest compressions especially in cases of out-of-hospital
cardiac arrest (Hazinski & Hunter-Wilson, 2011; Nolan, et al., 2010). Currently the new
guidelines have changed chest compression rate and depth. Also there has been the
addition of scene safety to help ensure that the responder or rescuer does not become a
victim by being aware of his/her surroundings (Hazinski & Hunter-Wilson, 2011).

Adults typically require CPR due to some form of cardiac arrest, and the chances
of cardiac arrest could possibly increase with age (Ewy & Sanders, Alternative approach
to improving survival of patients with out-of-hospital primary cardiac arrest, 2012).
Victims that are recognized as adults that require Adult CPR are adolescents that have
signs of puberty including chest or underarm hair in males and breast development in
females (Hazinski & Hunter-Wilson, 2011). Adult procedures in CPR are as follows:

Step 1: Assessment and scene safety
Step 2: Activate the emergency response system and get an AED
Step 3: Pulse check (carotid pulse)
Step 4: Begin cycles of 30 chest compression and 2 breaths (CPR)

Steps 1 through 4 are typical steps for Adult CPR. In the latest guideline change Step 4
would include defibrillation where an AED would be used to analyze the victim to detect
a shockable rhythm. The cycles are then repeated with at least a 2 inch depth for chest
compression and 1 second breaths that are sufficient enough to make the chest rise.
These steps generally change depending on the number of rescuers from using a single
approach to a team approach with divided procedural responsibilities among the rescuing
team members or party.
Another CPR procedure is based on responding to a child as the victim of a cardiac arrest event, and it has its own set of procedures. Children’s CPR has some similarities to adult’s CPR, but there are some changes. A child is described as someone 1 year of age to puberty. The compression depth is one third the depth of the chest or approximately 2 inches. Also 2 minutes of CPR can be provided prior to activating the EMS depending on whether the arrest was sudden or not. Children are younger and less likely to have cardiac arrest due to disease; therefore most cases may be respiratory related arrest. Team CPR also changes between child and adult where the compression ventilation ratio changes to 15:2 with 2 rescuers (Hazinski & Hunter-Wilson, 2011). A general child CPR procedure description is:

Step 1: Check for responsiveness
Step 2: Call for help
Step 3: Check pulse (carotid or femoral pulse)
Step 4: Begin cycles of 30 chest compressions and 2 breaths
Step 5: Activate the emergency response system after 5 cycles, and use the AED

As with Adult and Child CPR, there are also procedures for CPR that pertains to assisting an infant victim. The Infant’s CPR process is different from both adult and child CPR techniques. Infants are described as up to 1 year of age excluding newly born infants in the delivery room. Compression depth is at least one third of the chest depth, or approximately 1 ½ inches. Additionally team approaches reduce compression to ventilation ratio from 30:2 to 15:2 (Hazinski & Hunter-Wilson, 2011). A general infant CPR procedure is as follows:

Step 1: Check for responsiveness
Step 2: Call for help

Step 3: Check pulse (brachial pulse)

Step 4: Begin cycles of 30 chest compressions and 2 breaths

Step 5: Activate the emergency response system after 5 cycles, and use the AED

These general procedures for adult, child, and infant CPR are crucial components of the chain of survival, and identifying the category of the victim determines the process that should be used in response to a cardiac arrest event.

The chain of survival can be categorized into two categories the Adult Chain of Survival and the Pediatric Chain of Survival. Each chain has a sequence of steps that are provided to improve the likelihood of survival. It contains five links that represent a distinct sequence that should be followed to improve the survival rate of victims. Due to the interest of this study the adult chain of survival will only be elaborated upon. The five sections are immediate recognition of cardiac arrest and activation of the emergency response system, early CPR with an emphasis on chest compressions, rapid defibrillation, effective advanced life support, and integrated post-cardiac arrest care (Hazinski & Hunter-Wilson, 2011). The sequence of this process is demonstrated in figure 1.1.

![Adult Chain of Survival Diagram]

**Figure 1.1** Adult Chain of Survival

Along with recognition of the Adult Chain of survival, it must be taken into consideration that this study also focused only on the aspects of CPR procedure with respect to
healthcare providers preferably nursing students. The new guidelines have produced procedural differences between the general public bystanders and healthcare providers CPR, and the procedures described within this section reflect upon the general requirement expected to be met by healthcare providers.

**Attitude Towards CPR Training**

Attitude, performance, and knowledge in conjunction with the retention of these concepts are major categories affecting CPR (Coons & Guy, 2009; Sipsma, Stubbs, & Plorde, 2011; Donohoe, Haefeli, & Moore, 2006; Mahony, Griffiths, Larsen, & Powell, 2008; Celenza, et al., 2002). Recent studies have noted that attitude correlates with willingness, knowledge, confidence, motivation, self-efficacy and ultimately performance. Also in previous studies it has been shown that knowledge can influence attitudes and perspectives on performing CPR (Tanigawa, Iwami, Nishiyama, Nonogi, & Kawamura, 2011; Moran & Stanley, 2011; Sipsma, Stubbs, & Plorde, 2011; Donohoe, Haefeli, & Moore, 2006). Each of these concepts has varied with further education or reeducation on the topic of CPR, but they tend to remain widely unbalanced. As knowledge improves there have been studies to show improvements in attitudes towards CPR, willingness, confidence, self-efficacy, and performance (Tanigawa, Iwami, Nishiyama, Nonogi, & Kawamura, 2011; Kuramoto, et al., 2008; Makinen, Niemi-Murola, & M. Kaila, 2009; Hamasu, et al., 2009). Conversely, as a result additional complications arise such as fears and anxieties, willingness to perform CPR on strangers versus family members, and negative shifts in attitudes on standards, and a reduction in confidence in some cases (Hamasu, et al., 2009; Makinen, Niemi-Murola, & M. Kaila, 2009; Kliegel, et al., 2000; Niemi-Murola, Makinen, & Castren, 2007). These shifts may
affect CPR participants’ willingness and motivation to learn and retain the knowledge being taught during training sessions (Hopstock, 2008; Makinen, Niemi-Murola, & M. Kaila, 2009; Kliegel, et al., 2000; Coons & Guy, 2009; Moran & Stanley, 2011; Lynch, et al., 2005).

Knowledge and confidence can be considered a driving force to promote willingness and motivation (Hopstock, 2008; Makinen, Niemi-Murola, & M. Kaila, 2009; Kuramoto, et al., 2008). Self-efficacy is “one’s belief in one’s capabilities to successfully engage in a specific area of behavior”, or “an individual’s estimate of his or her ability to successfully perform a given behavior” (Hansen & Bubany, 2008). This definition implies that the above stated problems such as attitude, willingness, knowledge, motivation, confidence and performance all have some direct relation to self-efficacy, and the use of technology may be used to improve these categories.

In a study conducted to evaluate the attitudes of nurses towards new resuscitation guidelines with defibrillator usage the key factors that effected performance outcomes were attitude, knowledge of CPR, anxiety, and self-confidence. The study included measurements on the education and reeducation of CPR for medical students. Results indicated low confidence in nurses, but it also showed a positive relationship between knowledge, experience, confidence, and willingness in other medical students. Nurses were not confident in CPR situations and felt anxiety. Due to education, fear of injury, self-confidence, and individual or team competence, nurses’ performance and attitudes were negatively affected. Additionally, as a result some nurses were less willing to perform CPR and defibrillation, and some even believed that defibrillation should be left up to a doctor. The study also concluded that educational programs should be tailored to
improve self-confidence, ongoing assessment of practical skills and scenario management, pretesting core knowledge, and identify any negative attitudes (Makinen, Niemi-Murola, & M. Kaila, 2009).

**Virtual Reality Training**

Seemingly over time CPR’s disadvantages have shown tenacity in their ability to remain as improvements are made. Poor performance measurements observed nearly a decade ago are still evident in steps such as opening of the airway, rescue breaths, chest compressions, and many other steps during the CPR process (Hunziker, et al., 2011; Woollard, et al., 2004; Celenza, et al., 2002). It has been noted that there is an issue with variations in instructors’ teachings that may lead to improper training or a reduction of CPR knowledge during course training (Parnell & Larsen, 2007). There is also the issue of retention; where medical professionals' and bystanders' CPR knowledge and performance begins to degrade immediately after completing the certification course in most cases from 80% to 47% after a 12 month period (Christenson, et al., 2007; Ertl & Christ, 2007); Mahony, Griffiths, Larsen, & Powell, 2008; Parnell & Larsen, 2007). Additionally, traditional CPR training drawbacks may be related to attitudes and knowledge of individuals attempting to perform CPR (Donohoe, Haefeli, & Moore, 2006).

Throughout history training methods have changed as time progressed, and progression has definitely been shown in the repeated adjustment and improvements of the American Heart Association guidelines and procedures. Adjustments, new methodologies, or procedures are adopted to better serve the needs of the trainers as well as trainees, and the 21st century has had a heavy adoption of new technologies to improve
training and education (Lombardi, 2007). The integration of technology into training allows many trainees to gain a more in-depth perspective on training; while also providing them with a better understanding of multiple events and procedures (Hansen & Bubany, 2008; Vincent, Sherstyuk, Burgess, & Connolly, 2008; Wilkerson, Avstreih, Gruppen, & Beier, 2008). Some technological training and education innovations have considered methods that provide displays or visual representations of models or data such as virtual reality and visualization techniques (Lombardi, 2007). These methods can also serve a purpose in reinforcing CPR training. Using virtual reality and visualization, the practices of CPR can be expanded to provide a greater degree of procedural understanding as well as boost confidence, self-efficacy, concentration, and performance. (Canche, Narvaez, Chi, & Lianes, 2011; Creutzfeldt, Hedman, Medin, Heinrichs, & Fellander-Tsai, 2010).

Advantages of using virtual reality have been demonstrated in previous studies with showing some positive benefits. Virtual reality offers safe environments through virtual construction, immediate feedback and correction, repetitive learning, time and cost saving, and a high degree of control of situations (Corley & Lejerskar, 2003; Wilkerson, Avstreih, Gruppen, & Beier, 2008; Vincent, Sherstyuk, Burgess, & Connolly, 2008). One of the most important aspects of virtual reality is situation based training, and being able to have the user experience different variations in training quickly (Huang, Rauch, & Liaw, 2010). It can be used to enhance thinking to visualize abstract concepts of a difficult process, and allow the user to gain a better understanding of complex tasks (Kaphingst, et al., 2009; Hauptman, 2010; Patel, Bailenson, Jung, Diankov, & Bajcsy, 2006). It can be used to take a visual approach to traditional theoretical scenarios.
assisting in the communication of material from a different perspective, and give novice or inexperienced learners a chance to perform complicated, dangerous, rarely seen, and unpredictable task to promote readiness (Parsons & Rizzo, 2008; Semeraro, Frisoli, Bergamasco, & Cerchiari, 2009; Vincent, Sherstyuk, Burgess, & Connolly, 2008). Virtual training also provides a way to merge traditional training with advances in technology (Pan, Cheok, Yang, Zhu, & Shi, 2006).

Therefore, the purpose of this research study was to develop a mixed reality simulation to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. The questions that were addressed are: 1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? 2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? 3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? 4) What effect does time have on the retention of CPR participants between the control and treatment groups? The procedures used to answer these research questions measured retention of knowledge, performance, and attitude of pre-nursing students enrolled in a basic life support training course. The study included a pilot and main study with a control and treatment group in both for this research. The control group included no interventions to the traditional CPR training in both studies. The treatment group included virtual mixed reality as an enhancement tool to traditional adult CPR training in both studies. Traditional or routine class related examinations, and an adult performance check list were used in data collection for retention of knowledge and performance of the
participants. Surveys were also used to collect data on students’ attitudes toward the two types of training. This study allowed for a better interpretation of how a mixed virtual environment can be used to reinforce student CPR training.

Additionally, this research expands the knowledge in both areas of CPR and the use of virtual reality as a learning tool. CPR has been proven difficult to learn and perform correctly, which leads to more innovative ways to discover new and essential methods to teach CPR to improve retention of knowledge, performance, and attitudes towards CPR. There have been many attempts to modernize CPR, and the use of virtual reality as a learning tool may provide a means to ease the transition. Virtual reality has shown some educational benefits and assisting in describing complex processes or procedures in a visual way to help the user or person understand problems better. In this case virtual reality was used to conduct an environment to simulate an out-of-hospital cardiac arrest. This allowed CPR trainees to gain invaluable experience. Students were able to experience an out-of-hospital environment with related distractions that may occur to promote readiness in unexpected situations. This training provided a practical safe virtual training environment as opposed to a theoretical or imaged scenario proposed by traditional CPR training to improve students' environment awareness. In addition to identifying how students respond to the new 2010 Resuscitation Guidelines, which identify scene safety and being aware of their environment as a standard. Also performance checks, knowledge, and attitude measures were used to determine the usefulness of both traditional and virtual reality enhanced training sessions. This allowed the determination of usefulness of virtual reality as a teaching tool for CPR training.
The first chapter of this dissertation introduces the concepts of CPR, CPR training, and virtual training. It also provided brief detail into a problematic issue with cardiac arrest and why CPR is needed. This chapter summarizes the primary goals and a general description of methodology. Chapter two provided a discussion on literature pertaining to previous research that has been done in the area. It provides detailed informative summaries on previous literary results influencing CPR, and its modernization. It also included details on the uses of virtual reality in areas such as training and education. Chapter three describes methodology and procedures used during the research process. It discusses specific steps taken, and instrumentation used while conducting research. Chapter four is comprised of results summarizing data and group comparison results of both the pilot and main study of the research study. Chapter five, the final chapter provides a detailed discussion of data presented in chapter four and attempts to make logical conclusion of the final outcome of the research. It also identified limitations, and possible areas for future research spawned from the current research topic.
CHAPTER 2

BACKGROUND

Computerized Search

The databases that were used in the literature review were PubMed and Science Direct. The main terms that were used in the descriptive were first responder, virtual reality, virtual worlds, CPR, CPR attitudes, CPR training, and virtual education. For example a descriptive used in a search in the Science Direct data bases was “emergency first responder training”, which initially produced 4950 articles. After refining to the restriction of CPR only 138 results were produced. Similarly within the PubMed data base the key world was “virtual worlds” and the results that were produce were 175. After refining the search with the restriction of “Free full text available” the results were narrowed down to 24 articles. Multiple restrictions were placed on the descriptive terms used to reduce the volume of journal articles to easily locate the ones that were needed for this literature review. Many articles in this search were related to journals sources such as Resuscitation, the American College of Cardiology, the American Journal of Medicine, the International Journal of Computer Science and Network Security, the Journal of Medical Internet Research, Prehospital and Disaster Medicine, Computers and Education, the Society for Academic Emergency Medicine, and Patient Education and Counseling.
Literature Review

To gain a greater understanding of CPR practices and how virtual reality can serve as an enhancement tool, multiple literary resources were used. The combinations of these sources were comprised into relatable themes. Primarily, first responder training within this review was focused on traditional CPR training, and virtual training. These two make up the main theme categories, which are then composed of multiple subthemes to assist in illustrating the proposed research. The subthemes that are concentrated within traditional CPR training are CPR traditional education, attitude, performance, and simulation and technology for CPR training. Furthermore, these subthemes are linked to their own subtheme which was the skills and retention of CPR. The other main theme virtual training is composed of two subthemes. These subthemes are virtual simulation/environment and virtual reality in education.

Traditional CPR Training

CPR training is generally offered to anyone willing to participate throughout many communities. That brings the issue of community competence in CPR to the forefront, which Celenza et al., (2002) has elaborated on. The primary objective was to determine community application of CPR skills in an emergency situation. Simulating an emergency situation allowed the participants’ performance skills to be assessed. Those assessments assisted in determining the relationship between CPR competence and training programs throughout the community. These community courses allowed not only medical professionals, but also bystanders to obtain CPR certified training. It’s very important for bystanders or lay person to have competent CPR training, as well as professionals, due to a multitude of cases of cardiac arrest occurring outside of medical
facilities. In typical cases of ventricular fibrillation that is witnessed in conjunction with a response by a properly trained individual could improve the victim’s chances of survival by at least 42 to 65 percent. This study was conducted in Western Australia and evaluated the performance of the communities in that area related to CPR. It documents both theoretical knowledge in simulated cases and its competence relation in a practical scenario. A cross-sectional telephone survey of metropolitan Perth and rural Western Australia was used to randomly choose 803 adult respondents. The survey had a 55% response rate, with the gender and age being consistent with the general population. The sample of n=803 were issued a five multiple choice questionnaire that was used to assess the participants knowledge during the emergency scenarios. The questions related to a victim having chest pains then collapsing; this allowed the author to generalize the level of theoretical knowledge of the participants. There also was a subsample taken from the 289 volunteers which contained n=100 metropolitan participants, and they were used for the purpose of face to face CPR skill assessment. In the subsample the age was not generalizable to the population, and two assessors simultaneously and independently observed the participants using a ten item checklist and rating scale that was previously validated. Results from the theoretical testing suggest that trained respondents are more willing to start CPR immediately, while untrained respondents would first activate the emergency medical service (EMS). The results from practical competence related to training used inter-rater reliability between two observers and Spearman’s rho, two tailed test to determine significance between scores of all individuals at alpha level = 0.01, and there were significant differences in the mean penalty scores. Repeated training up to five times or more showed a significant training effect with increasing the frequency.
This assisted in concluding that trainers should use available resources such as bystanders; this inclusion can make a significant impact in the chain of survival from cardiac arrest.

Using bystanders as a means of combating cardiac arrest until the proper authorities arrive has been identified as a critical step in the chain of survival, but there is an associated issue based on the actual performance of the CPR procedure (Parnell & Larsen, 2007). Typically CPR standards are revised by the American Heart Association (AHA) every 5 years or so, and the reasons for these revisions are to improve the chances of resuscitation from CPR. A debatable issue is the ratio of chest compressions to ventilation. As discussed in the study by Hostler, Rittenberger, Roth, and Callaway (2007) the concept of increasing the amount of chest compressions to ventilation could improve the delivery of CPR (Hostler, Rittenberger, Roth, & Callaway, 2007). Circulation of the oxygenated blood within the body is a critical product produced when performing CPR and that manages to put even more emphasis on increased chest compression. Previous ratios before this change were 15:2, implying 15 chest compressions to 2 breaths or ventilations, and the new recommended ratio concluded by this study is 30:2. The research was conducted on a sample of n=875 municipal firefighters with t-test being used to do the statistical analysis. Although analysis was restricted to the first 3 minutes of CPR; the results show that there is a significant difference with pre-protocol (15:2) ratio and post-protocol (30:2) in delivering chest compressions and the rate of return of spontaneous circulation (ROSC). The ROSC values were for pre-protocol 32.3% and post-protocol 42.4%. Finally this concluded that
a higher compression to ventilation ratio of 30:2 should be used to retrain CPR trainees to produce a more effective CPR technique.

**CPR Traditional Education**

Typically CPR courses are taught in a classroom setting, and the instructor provides participants with information on the AHA guidelines and how to perform CPR techniques. Multiple courses are taught by different instructors, and this can cause variations in learning the same procedure. This can lead to knowledge gap between participants, and depending on the material the instructor teaches during the course. Parnell and Larsen (2007) are two authors that have studied the issue of poor quality teaching in lay person CPR courses. Their study indicates that poor CPR is commonly performed when attempting to resuscitate a victim of cardiac arrest. Their study results not only indicate the poor performance of CPR by bystanders or lay persons; it also includes medical personnel. 14 CPR courses were investigated in during the study, and all courses complied with the New Zealand Qualification Authority (NZQA) standards. Over a 6 month period, observations were held at 7 small private providers and 7 larger multi-centered providers. The author notes that there is a distinct difference in what is being taught in each course, and an even greater difference when comparing a small provider to a larger one. The data was statistically represented as a descriptive number and/or percentage of courses; test such as the unpaired t-test for continuous variables, chi-squared test for discrete variables were used. Statistical significance was declared if p<0.05. Primarily questions pertained to the differences in CPR courses being taught, how different are the environments, and how did they differ in teachings. The results in the study demonstrates the variations in CPR course teachings such are rushing trainees,
not spending the proper amount of time on material, and omitting material. Their study raises many concerns about the actual teachings passed on to the community by NZQA approved courses, including are trainees properly prepared to perform CPR effectively with a competent technique, since the NZQA standards does not allow sufficient time for skill acquisition and competence.

A study was conducted by Perkins et al., (2008) which also indicate that poor quality CPR not only affects BLS, it also has effects on advanced resuscitation training. After the new European Resuscitation Council set in place new guidelines, their study was conducted to demonstrate the poor quality CPR performed during advanced resuscitation training. One motivational concept for this study is based on the significant short falls of CPR performance that has been recorded by observers. In their case, the authors state that education is a key part of ensuring that resuscitation is successfully implemented, and advanced life support (ALS) is a conduit that assists in the implementation. The setup of the study was based on cardiac arrest simulations ran and observed by two paired instructors. Data collection was conducted on doctors, nurses, or others in two phases; these phases were introduced at different time intervals. Phase 1 containing 46 subjects, and phase 2 containing 48 subjects. Phase 1 was prior to the change in resuscitation guidelines with same 15:2 ratio, and phase 2 after the guidelines had been implemented with the 30:2 ratio for compressions to ventilation. Statistical analysis for measurement included the use of SPSS 14.0 for windows using the two way repeated ANOVA measure to analyze change in performance test results, and nominal data was analyzed using chi-squared or Fisher’s exact test. These 94 subjects were used to gather data on the investigation of CPR performance before and after the introduction
of the new criteria. The statistical analysis showed a 25% change in chest compressions per minute, which indicated a greater requirement for power from the participants compared to previous standards. Results indicate that there was no significant difference between the participants in both phases, but there was a delay in chest compressions in both groups. There also was no evidence of improved chest compression depth, which was required by the new standards. These findings indicate that not only bystanders but professionals also have an issue with inadequate compression depth, prolonged interruptions of chest compressions, as well as other inadequacies that demonstrate a lower competence in CPR techniques.

Christenson et al., (2007) produced a study based on the deterioration of CPR skills during training and retraining. The authors make reference to the process of performing CPR as being difficult to teach. The training and retraining of individuals with groups composed of no more than 12 members occurred within 3, 6, 9, or 12 months. Statistical analysis include Kruskal-Wallis test for computing composite scores, and ANOVA F-tests for linearity when computing training and retraining time. These tests were used to indicate how long bystander participants’ CPR knowledge was retained. Results from this study indicated that 80% remain competent up to one year after receiving CPR training. The authors also specifically states that their results are in contrast to many previous CPR skill retention studies, and it may be a direct result of the study design and different study population. They also comment that it is unknown whether passing or failing scores in their environment reflect the ability to perform CPR. As a limitation of the study when compared to previous skill retention studies which evaluates multiple skills; their main measure of competence in an overall manner focused
on compressions. Instead of using a more common or typical evaluation method which combines a combination of skills to measure a complex task, the authors took a more simplified approach in determining competence after a 12 month period. This may have been the reason that could have led to such a high turn-out in CPR competence, which conflicts with multiple reports in previous and current research. Due to many of these inadequacies, attempts have been made as a means to identify new and improved methods for the delivery of CPR training.

**Simulation and Technology for CPR Training**

Integrating the use of technology into CPR training may serve as a medium towards increasing retention among trainees. There has been many options explored in the attempt to improve CPR performance and some implore the use of multimedia such as mobile devices (Ertl & Christ, 2007; Canche, Narvaez, Chi, & Lianes, 2011; Lynch, et al., 2005). While some may prefer the use of a machine to actually provide CPR skills such as chest compressions, various attempts are being made to successfully integrate technology into CPR practice (Yost, et al., 2012). These approaches are all developed as a counter measure against poor CPR technique and skill performed by both bystanders and medical personnel. Although more attention has recently shifted towards the proper education of bystander as the front line defense against out of hospital cardiac arrest performances still remains poor.

Ertl and Christ (2007) were two researchers that attempted to provide a significant improvement in bystander first aid by introducing an expert system in conjunction with mobile multimedia devices. Their study communicated the importance of bystanders gaining a better understanding of first aid usage could eventually increase the chances of
survival for victims. A personal digital assistant (PDA) device was used containing an expert first aid system to provide reference to resolutions to 101 untrained lay-helpers. The lay-helpers were presented with two emergency situations which involved a trauma victim with severe bleeding, and another that required CPR to be performed. The primary focus was to investigate the use of the PDA and expert first aid system as a means to significantly improve the quality of pre-hospital emergency care. The participants were split into two groups with one group of 49 participants using the PDA device and first aid system, while the other 52 participants were assigned to the control group without any computer assisted help. Participants were statistically analyzed using the t-test and SPSS v.12.0 statistical software. The result from the analysis concluded that the group with PDA assistance overall scored higher in both stations of the study, even though both groups had experience with BLS. They also noted that it was a considerable difference between the groups with PDA users outscoring the control group in the areas of airway management, CPR, recovery position, and applying dressing.

Another study by Lynch et al., (2005) attempted to demonstrate the effectiveness of a 30 minute CPR self-instruction program for lay responders. An older demographic of laypersons were used in their study with individual ages ranging from 40 to 70 years old. Participants were generally selected by a response to a CPR training study advertisement in the Portland, Oregon area, and each participant had to at least had some form of CPR training within the past 5 years to be considered for the study. Their goal was to use a controlled randomized design to determine whether reduced training in basic CPR skills will translate as well as Heartsaver courses. The experimental design was composed of three groups the control with no intervention (C), the traditional Heartsaver
adult CPR class (HS), and the self-training intervention. These groups were composed of the 285 participants. The emphasis was put on the self-trained group which consisted of three subgroups that were self-training alone (ST), self-training with instructor facilitation (ST-I), and self-training with peer facilitation (ST-P). Primarily the self-training scenarios implied the use of a 22 minute video instruction on CPR, an inflatable mini anne manikin, and a CPR coach device. Statistical analysis for each group was done using ANOVA statistics with a cronbach’s alpha with estimated reliability of 0.81. Their study demonstrated that the self-trained group performed adequately, and the effect was as great as the traditional Heartsaver training. It also showed the group using the CPR coach produced a reliable advantage for overall CPR performance and ventilation when compared to the other two groups. Their research provides additional support for use of technology as a means of improving BLS and CPR skills.

In addition a study conducted by Yost et al, (2012) gives further insight into mechanical chest compression, as a result of the inadequacies of manual compression performance done by individuals including medical personnel. Their study looks at the assessment of CPR interruptions from transthoracic impedance during use of the LUCAS mechanical chest compression system. The authors identify a gap in the literature base on the interruption of mechanical compression systems used for CPR purposes. In this analysis, pause lengths including pre and post shock delivery during the application of LUCAS, which were then compared to actual measures of pause lengths by analyzing transthoracic impedance data gathered by defibrillators. Software was used to analyze the compression fraction, and compression rate. There were also measurements used at times when assembling portions of the device, which provided interruption time. The
sample size of participants that actually provided data in this study was 32 of 113. Results and observations of multiple providers’ data indicated that interruption of chest compress can vary from 10 seconds to over 100 seconds, which conflicts with the current CPR standards of the AHA. Although the limitations of the small sample size of 32 was used during this study; it provided great detail in the unacceptable delay or interruptions when using the LUCAS mechanical compression device for CPR on victims of cardiac arrest. This study shows that the integration of fully mechanical devices into CPR procedures with little human involvement can be difficult to maintain due to the possible variations in procedures and results. Therefore there is still a need to improve the skills of individuals that perform CPR until better consistent systems can be developed.

In the process of attempting to improve individual CPR quality and performance there has been an increase use of simulations to promote preparedness among training candidates (Canche, Narvaez, Chi, & Llanes, 2011; Hunziker, et al., 2011). One of the most important concepts of these simulators relates to the topic of how they should be designed to ensure a smooth transition and implementation into the classroom or traditional training. In a study conducted by Maximiliano Canche, Lizzie Narvaez, Victor Chi, and Erika Llanes in 2011 at the Universidad Autonoma de Yucatan, Mexico focused on using an educational simulator for training CPR skills. They identified the design and implementation of an educational simulator to assist people in the medical field training using their CPR skills. Additionally, the study also used the educational simulator as an evaluation tool to assist instructors in the evaluation of trainees by coordinating performance learning percentages of each individual. The main goal of this study was to help improve the learning process for cardiac arrest treatments through an
electrocardiogram simulator giving traces and cardiac treatment. The authors of this study agreed that there have been many attempts at improving CPR such as the development of electronic resuscitation evaluation systems by Patrick and Eisenberg in 1972, the simulation of a whole patient for class training by Compton and Patel in 1998, the design and development of a medical parallel robot for cardiopulmonary resuscitation by Yangmin and Qingsong in 2007, and a system to improve AED resuscitation using an interactive CPR coaching by Licher, North, Andre, Riehle, and Anderson in 2009. Therefore the authors decided to create an educational simulator based on CPR treatments to identify both traditional learning processes and evaluation of CPR which incorporated both education and evaluation. The training simulator’s design used visual representations provided using a Unified Modeling Language (UML) for comprehension purposes; that combined the best practices of diagramming applied to object oriented software development. Simulator design was composed of a collection of diagrams and text which described how the user hopes to interact with the system, and general functionality included two modes which were practice mode and evaluation mode. Activity or interaction during simulator training was controlled by the use of structures which represented the system responses to the user, how objects are created and manipulated, and how data is stored. Results of this study showed that simulators are powerful tools for teaching new techniques, procedures and instrument, and can be used to help people get a better understanding of patient complications, appropriate use of tools and instruments, and the skills to perform a procedure. It also recognized the ease of customization of simulators for medical practice, and their ability to provide a better evaluation of activities and knowledge. The authors also conclude that many parameters
relating to simulators will be the object of future studies and among those are:
effectiveness of simulators as a teaching tool, usability, and an investigation of the
relationship between CPR skills and their evaluation process.

**Skills and Retention of CPR**

Retaining the knowledge from CPR training has proven to be difficult for many
trainees. The use of simulations and other technologies have been used as a means to
increase the retention of CPR related skills, but there still remains a degradation of
knowledge after completing the course (Mahony, Griffiths, Larsen, & Powell, 2008;
Woollard, et al., 2004).

Mahony, Griffiths, Larsen, and Powell (2008) conducted a study on a simulation
that focused on the retention of knowledge and skills in first aid and resuscitation by
airline cabin crew. Their study was an investigation to determine the retention of CPR
and AED skills, first aid knowledge, and perceived level of confidence among a sample
of 35 cabin crew members a year after training. The training of the crew was based on
the New Zealand Resuscitation Guidelines. Test scenarios tested each participant to
determine if the participant could adequately manage a situation in previous training
without assistance and with only the available equipment for 10 minutes. The crew was
also given a questionnaire which consisted of three questions to assess self-assessment of
performance and knowledge or previous training. Participants were rated on self
confidence in CPR skills, using the AED, first aid knowledge and first aid skills using a 5
point Likert scale. SPSS 14.0 was used to do the descriptive statistical data analysis and
Pearson r was used for correlation of the data. Participants were also tested on their
performance of CPR consisting of the approach to the patient, airway, breathing, and
circulation, chest compressions, and AED usage. Results of this study showed that 26 of the 35 indicated low confidence in CPR skills, and in theoretical knowledge, and 20 of the 35 crew members provided additional information beyond the scope of the curriculum. This study demonstrated that there is a decline in CPR and AED skills following training that is demonstrated in both laypersons and medically trained persons. Majority of the crew lacked adequate performance of CPR skills that were required. Although their study suggested that the crew possessed a high level of experience in first aid and some CPR and AED experience the retention levels showed to be unacceptable. Performance of the 35 members showed that 33 subjects failed to use the bag-mask correctly, 18 performed chest compressions at the incorrect site, only 13 achieved the correct compression depth, and only 20 placed the AED pads correctly with a first shock delay average time of 110 seconds. Due to low performance quality it is suggested by this study that existing approaches require further investigation and modification.

A previous study from Woollard et al., (2004) suggested similar results on skill acquisition and retention in automated external defibrillator (AED) use and CPR by lay responders. Their study consisted of a sample of 112 trainees that were immediately tested before and after the four hour course, and 76 of the 112 trainees participated in follow-up refresher training. The subjects were 18 years of age or older, and were airport employees who volunteered for the Department of Health, England National Defibrillator Program. The training programs in this study were meant for responders that were not healthcare professionals, but may be deployed to a scene of cardiac arrest. Evaluation and testing of performance of each participant was observed using a Leardal Recording Manikin and video recording. This method showed strong intra-observer reliability and
modified versions of the previous Cardiff Assessment of Response and Evaluation test were used to show validation. Data analysis was conducted using SPSS with p values and 95% confidence intervals to test self-assessed competence and confidence scores. Skill performance was measured using Arcus QuickStat, and Spearman rank correlation related associations between self-assessed competence, confidence, and time to first shock after basic training. Also the author made use of the Fisher’s exact test when comparing the demographics of the group of 112 trainees. The results showed that there was a decline in CPR and AED knowledge after 6 weeks despite having 59% of participants trained in CPR training, and refresher courses have the ability to improve later performance to a level above initial training.

**Attitudes Towards CPR**

CPR training has faced many issues in the area of performance and retention, but there are also issues that CPR training is facing concerning attitude. A person’s attitude may affect the way that he or she views unfolding events. It also can effect he or she in a way of doing specific task. In recent literature, attitude has become a major factor in determining CPR performance and outcomes. Studies have focused on areas of attitude such as willingness, motivation, self-efficacy, and more. Studies have also been conducted that are even location specific to determine if that affects attitude as well. Studies have indicated that there are many varying aspects of CPR training and performance that attitude can effect.

Hamasu et al. researched a topic based on the effects of BLS on factors associated with attitude towards CPR in college students in 2009. The study identified factors associated with the willingness of college students to perform CPR. A key component
such as willingness was identified as a possible means for combating out-of-hospital cardiac arrest by promoting willingness to perform CPR among the public. Additionally it is also stated that the bystander CPR rate was reported to be less than 30 percent for the last 10 years in Japan prior to 2009. The student sample was composed of 259 students that completed the questionnaires, and a logistic regression model was used to clarify independent factors for their willingness to attempt resuscitation. An evaluation questionnaire was composed of 15 categorical and Likert-type question pertaining to knowledge and attitude towards BLS, and was used to test the students. The results of this study also reinforced the outcomes of previous studies on attitude in conjunction with BLS or CPR, which demonstrates the consistency of problems plaguing BLS. Hamasu et al. concluded that there are dramatic changes in student’s attitude before and after BLS training in small groups, and after the training “anxiety of infection” and “anxiety for being sued because of a bad outcome”. Also it was noted that customs or culture could have an influence on resuscitation efforts, therefore more emphasis on hands only CPR could possibly mediate cultural reluctance to perform traditional CPR. From this study it can be easily seen that there are both attitude barriers from lack of education as well as barriers developing from education.

Tanigawa et al. designed an observational study in 2011 in Takatsuki, Japan to help answer the questions of preparedness to perform CPR. Specifically they address the issue of are trained individuals more likely to perform bystander CPR. The aim of the study was to evaluate the association of CPR training with bystander performance and patient outcomes after out-of-hospital cardiac arrest. The proven effectiveness of bystander CPR has the probability of improving sudden out-of-hospital cardiac arrest
situations, but bystander CPR remains infrequent. This study’s design included a time period from January 28, 2007 to December 31, 2008. All participants were above the age of 18 who suffered out-of-hospital cardiac arrest and were treated by EMS personnel, and their rescuers were also included in the study. Approximately 200 people had suffered out-of-hospital cardiac arrest therefore there was a need for at least the same amount of rescuers. All data analysis was done using SPSS version 16.0 using methods such as chi-square, Fisher’s exact test, Student t-test, and Mann-Whitney U test to determine the relationship between bystanders’ previous CPR training and performance. Participants’ demographics that were associated with having influence in previous studies were also categories in this study, and two-tailed value of p<0.05 indicated significance. Study results of these 273 adult out-of-hospital participants were documented along with 253 cases of attempted resuscitation by EMS. 170 subjects met inclusion criteria and interviews were completed for 120 cases. The author concluded that bystander CPR is more likely to be performed by trained individuals. Bystander CPR is strongly linked to improve patients’ survival, and trained individuals would have a better outcome. Also they state that further studies are needed to prove the effectiveness of CPR training on survival.

In search of response to newly created resuscitation guidelines Miki Enami, Yutaka Takei, Yoshikazu Goto, Keisuke Ohta, and Hideo Inaba devised a study in 2010 in Japan pertaining to the effects of the new CPR guidelines on attitude toward basic life support. The actual study period was from January 2007 to April 2008, which adhered on the most recent 2005 resuscitation guidelines. Participants in this study were generally recruited through driver license courses that provided BLS training, and were
new applicants from 17 authorized driving schools in Japan. Participants were also part of this two term study which had two groups which were determined by dates in attendance. These two time periods were January 2007 to April 2007 and October 2007 to April 2008. There was a final total of 3580 before the book was revised and 5310 respondents after the revision. Some participants were excluded due to incompletion of the provided questionnaire. Results from this study showed that the majority of the participants were between the ages of 17 to 29 with little difference in age, occupation, and residential areas in both terms. There also was an indication of an increase in participants’ knowledge for AED usage from 40.3% to 50.5% after the text book revision, but there was no significant increase in their willingness to perform CPR on their own initiative between both terms. These results led the authors to conclude that guideline renewal increased positive response to AED usage and all the other BLS actions. However, it also provided unwillingness in the areas of early call, CPR on one’s own initiative, and telephone assisted chest compression. The author suggests that the emphasis should be placed on the benefits of placing an early call, telephone assisted CPR instruction, and awareness of participants backgrounds relating to their willingness.

Miki Enami et al. also conducted a similar study to observe the differential effects of aging and BLS training experience on attitude towards basic life support in 2011. The primary objective of this study was to determine the effects of aging and training experience in regard to attitude towards performing BLS. This study identifies with actions that are crucial to the chain of survival to increase the likelihood of survival of out-of-hospital cardiac arrest, and negative impact has been shown to occur if there is a delay in performing those actions such as an emergency call. Enami et al. also expressed
the issue of citizens’ attitude toward CPR and AED use with several reasons why bystanders may be reluctant to initiate CPR and use an AED. Participants for the study were again among new driver’s license applicants attending one of the 17 authorized schools in Japan. Participants were placed in age groups which were the younger group (17 -29 years old, n = 6122), middle aged group (30 – 59 years old, n = 827), and old or elderly group (59 years old and greater, n = 15,743). These groups were studied for a period of two years from May 2007 to May 2009. The results of this study came from the collection of all 25,922 participants with no regard of blank responses. Some participants’ answers were excluded due to not providing enough background information during testing. Results included comparisons of background characteristics among age groups, willingness to perform BLS among groups, and the estimation of acceptance rate of telephone-assisted CPR instruction. The authors expressed the limitations of the study as not being able to properly represent the willingness of the middle aged group, and suggest further study is needed to clarify willingness within this group. Overall the author concludes that more negative attitudes are more associated with the aged populations. More respondents were willing to support telephone assisted instruction of compression only CPR. Prior BLS training did not reduce unwillingness to make an early emergency call, and non-elderly respondents were more willing to use an AED.

Out-of-hospital arrest has also been a key issue in understanding bystander attitudes towards performing CPR. An investigation was launched by Stephen Coons and Mignonne Guy to further elaborate upon the subject. They conducted a study in 2009 based on performing bystander CPR for sudden cardiac arrest behavioral intentions
among the general public in Arizona. The authors here acknowledged the importance of bystander resuscitation efforts, but there also is acknowledgement of the many cases where CPR is not received. They admit that literature has provided evidence that is susceptible to double interpretation or equivocal when identifying factors that promote unwillingness to perform traditional CPR. This study proposed a way to increase the number of individuals willing and able to perform CPR in out-of-hospital cardiac arrest.

The population of this experiment included a randomized distribution of mailed surveys to both rural and urban counties in Arizona. The sample was composed of 850 names and addresses of residents 18 years old from the counties of Maricopa and Santa Cruz Arizona. Self-Administered questionnaires that were useable were from 49.5% (n = 370) rural and 49.6% (n = 385) urban counties participants. T-test was used for differences in mean age between urban and rural groups. Wilcoxon Rank-Sum (Mann-Whitney) test was used to determine if there were differences between the two groups. They used frequencies to compare differences in training, performance, and willingness to perform CPR; those differences were assed using the Fisher’s exact test. There also was usage of the chi-squared “goodness of fit” test to compare questionnaire categories based on the stranger and family categories. The authors also used exploratory logistic regressions models to identify predictors of willingness to perform CPR based on age, sex, residence, language of questionnaire completion, and CPR training as independent variables. The author did however identify predictors that effected willingness of the respondents.

Being younger, male, having had CPR training, and living in a rural area were predictors of willingness to perform CPR on a stranger. The same predictor values were associated with performing CPR on a family member with the exception of living in a rural area.
Results of this study indicated that approximately 45% of the respondents would not perform CPR on a stranger for various reasons. 55% of the respondents with CPR training were more likely to report being willing to perform CPR, but many of them also reported unwillingness to assist a stranger. A large number of respondents feared legal consequences, improper performance of CPR, and mouth to mouth contact (fear of disease). Although they did not collect data on chest compression only CPR versus traditional CPR the author state that will not reduce or eliminate all the barriers to performing bystander CPR. This assumption was due to more than 80% of respondents having reasons for unwillingness besides mouth to mouth contact. The study did serve the purpose of informing the public as a health initiative aimed towards changing attitudes and beliefs toward bystander CPR. They allow one to identify with a person’s inability to perform CPR based on physical capabilities, situation, environmental factors, and presence of other bystanders. They concluded that much more could and should be done to increase the number of people willing and able to perform CPR in Arizona and beyond.

In 2009 Makinen, Niemi-Murola, Kaila, and Castren felt that it was a good idea to investigate nurses’ attitudes towards resuscitation and national resuscitation guidelines to better understand the reasons why nurses hesitate to perform CPR with defibrillation (CPR-D). These tests were conducted in Finland on the basis of the new national resuscitation guidelines that were updated in 2006. These guidelines were based on the international resuscitation guidelines published by the European Resuscitation Council (ERC) in 2000 and updated in 2005. One main change in particular to these guidelines was the use of defibrillation, which could be performed by nurses who are usually the
first on the scene with an automated external defibrillator (AED). The change caused nurses to adjust to a new task that was usually performed by physicians. The authors also suggested that first-responder defibrillation performed by nursing staff should be considered as the first link in an in-hospital chain of survival. The process of adjusting the idea of nursing performing defibrillation seemed slow at best. One year after the new publication of the 2000 international resuscitation guidelines there were only about 27% of nurses in Finland that had taken defibrillation training, and automated defibrillators were of uncommon use with nurses only performing defibrillation at a rate of 15% in general wards. In 2004 there was a slow increase to a rate of 67% for rapid defibrillation programs in hospitals. During the study in 2007 the hospital renewed their defibrillators giving most nurses access to an AED (77% vs. 15%), and (19% vs. 33.4%) had manual defibrillators or no defibrillator. The study showed that although guidelines had been introduced they were not being implemented actively, and despite training nurses still hesitated to use AEDs in resuscitation situations. Some cases the AED would never be deployed for use. The authors makes reference to literature that suggest that individual’s beliefs, attitudes, and knowledge have been shown to influence professional behaviors, and suggest that this reluctance to perform defibrillation may be due to the individuals or organizational attitudes. Therefore the authors decided to use this study as an educational intervention measuring the effects of CPR-D and Finnish national resuscitation guidelines in secondary hospitals with pre and post surveying. The study design required a questionnaire to be mailed in December 2003 and January 2007 to most senior nurses in a single hospital. Those senior nurses distributed the questionnaire to all nurses working on their wards (n = 361 in 2003, n = 361 in 2007). The participant
sample consisted of all nurses working in a medium-sized secondary hospital in Southern Finland (8 wards and 152 beds). The population included all the nursing personnel within the secondary hospital and consisted of all 361 nurses in both 2003 and 2007. The actual group turned out to have $n = 297$ of 361 participants in 2003 and $n = 199$ of 361 in 2007. Nurses had various backgrounds from all inpatient specialties such as internal medicine, surgery, pediatrics, geriatrics, gynecology, and obstetrics. The questionnaire that was given to nurses contained 48 questions on a 7 point Likert scale (Strongly Totally Disagree to Strongly Agree) to measure attitudes towards CPR-D and new resuscitation guidelines. The questionnaire included a validated attitude towards guidelines scale (AGS Statistical analyses used cronbach’s alpha to calculate the questionnaire’s reliability Results from the questionnaire showed a cronbach’s alpha greater than 0.66 (2003) and 0.65 (2007). There were significant differences in the nurses’ attitudes before and after CPR-D educational program. More confidence was noticed in nurses’ ability to perform defibrillation after the education. There was still hesitation in over a quarter of the nurses in performing defibrillation. They experienced fear of injuring the patient (27.7% in 2007 vs. 41.4% in 2003, $P<0.001$). Two thirds hesitated before commencing CPR because of anxiety (64.4% in 2007 vs. 22.9% in 2003, $P<0.001$). The author noted that education did not change attitudes towards resuscitation guidelines, where were already positive. Nurses believed that the new guideline improved upon patient care and interactions between patients and health care personnel. There were draws backs to the nurses’ education. It actually increased negative attitudes towards guidelines from an organizational stand point. Education also did not improve attitudes towards implementation, but after education nurses felt less often that the new
guidelines would change their roles (28.2% vs. 38.7%, P<0.001). There were quite few nurses that felt that the new guidelines would change the roles of nurses (45% vs. 39%, P<0.001). Negative attitudes guidelines were correlated significantly with the scale attitudes towards CPR-D (P<0.01). One of the most important factors that affected nurses was the fear of the patient dying and feeling guilty. Willingness to defibrillate correlated significantly with knowledge of the rhythms associated with resuscitation (P<0.001). After educations the nurses still considered there CPR-D education unsatisfactory, although their education was more significant than before (41.5% vs. 49.4%). Similarly there was the same feeling about cardiac rhythms (43.2% vs. 45%). There was also a significant correlation found between age and latest CPR-D education within the scales of attitudes towards CPR-D, negative attitudes towards guidelines, attitudes towards implementation, and attitudes towards nurses role (P<0.01). During the discussion of the results the authors state that the basic education of nurses has been poor, and leaving nurses unprepared for CPR-D, leadership, increase demand for changes in training, regular training, and evaluation at work. It has been recorded in literature that the resuscitation skills of health-care personnel are inadequate. They stated that the lack of resuscitation education and poor skills among nurses have also been confirmed in previous studies. The Hawthorne effect cannot be excluded; meaning some members may perform differently (improving or modifying behavior) due to the factor of them knowing that they are being tested as well. The conclusion of this study is that educational programs can increase the nurses’ confidence in their own CPR-D skills, and create a positive atmosphere towards nurse defibrillation. There was no reduction in anxiety in resuscitation situations, and fear of harming the patient was still present. The
authors suggest that retraining intervals of 6 months would be sufficient upkeep of BLS skills especially for nurses that do not get to practice BLS skills often. Also tailoring education programs should place attention on self-confidence of the nurses through CPR-D education on defibrillation training and teamwork, exploration of the reasons for negative attitudes, and the change of negative attitudes in organization through introducing multi-professional education.

A study aimed at unraveling the mystery of motivation and adult learning for hospital personnel attending CPR courses was conducted by Laila Arnesdatter Hopstock in 2008. The objective of the study was to determine the relationship between motivated participants and their learning potential, and whether there is a correlation between individual motivation and adult learning. The author states that less than 20% of all in-hospital cardiac arrest patients survive, which is a daunting observation. There is an issue of ineffective, costly, time-consuming, and poor skill retention without regular retraining. The author considered increased motivation as important principle in adult education, and it could possibly be used for CPR learning. CPR education using established reliability and validity tested instruments are scarce when considering motivation as an influencing factor. Therefore the author has identified motivation as a key factor of this study in the investigation of CPR adult learning. In this study motivation has been broken down into key areas. The author uses modern expectancy learning theory, social cognitive learning, and personality theory to define a connection between motivation and adult learning. The author uses self-efficacy and task values to measure the degree of engagement and effort and persistence to show the individuals learning of a specific task. In reflection upon adult learning the author refers to Knowles assumptions on adult learning, which were
used to study learning principles among hospital personnel. Knowles uses six assumptions based on adult learning which are the need to know, self-concept, prior experience, readiness, orientation of learning, and motivation. Motivation is considered one of the internal factors that drive the will to learning. Test of the motivation factor was performed during the time period of 3 months in the autumn season of 2006, and a survey was administered to all hospital personnel attending CPR courses teaching BLS with and without AEDs at three Norwegian hospitals. The instrument was specially tailored toward the CPR course. Data was collected from 3 hospitals before the start of the course. SPSS was used for statistical analysis. T-test for independent samples was used to make comparisons between groups with an alpha level of significance at 0.05. Results of this study showed that of the 362 participants 361 completed the survey. There was a mix of professions from registered nurses (57%), enrolled nurses (16%), bioengineers (8%), clerk personnel (6%), radiographers, physiotherapists, and occupational therapists (4%), physicians (2%), and others (7%). Of the respondents there were a total of 149 that had been prepared for the course with information on CPR before they attended the course. 254 respondents decided to take the course based on their own decision, or in cooperation with department heads. 187 of the respondents worked in high risk areas associated with cardiac arrest. Statistical results reported a cronbach’s alpha of 0.87 for task value and 0.91 for self-efficacy. Task value and self-efficacy were correlated with a Pearsons r =0.55. The author drew a conclusion from the data that respondents who worked in high-risk areas for cardiac arrest and/or were nursing personnel considered CPR skills as more important than low risk area related personnel with other professions. The author describes why the areas of preparedness,
participation, readiness and relevance are important based on Knowles theory. In preparedness the idea of participants knowing the material prior to attending the course can greatly effect motivation. It allowed the participant to understand why, what, and how he/she is learning, and consequences of not knowing why according to Knowles are decrease in interest and motivation. It is also stated that this study shows that consciousness of the importance of knowing CPR skills may increase learning motivation as a task value. Additionally repetition could increase self-efficacy to perform well in the course. As a part of adult learning it is import for the individual to recognize the importance of the information learned and understand how it is relevant to him/her. This study suggested that having decision making capabilities correlates positively with motivation. It can be considered the feeling of having the choices in learning, which is important as an adult, but it does not affect self-efficacy. Readiness and relevance is more closely related to work professions and conditions. Respondents that worked in high-risk areas for cardiac arrest and/or were nursing personnel were more motivated to learn CPR than other hospital personnel. They also had higher levels of task value and self-efficacy when compared to the others. Knowles has stated that adults seek learning of skills necessary in real life situations and are problem-centered in their learning, and these participants’ CPR learning motivation factor could simply come from the possibility of being a first-responder. The author mentions two contrasting arguments within this study which are high-risk area personnel with special interest in CPR education are able to perform high quality CPR, but conversely studies support poor CPR quality from among hospital personnel. The author suggests that motivation and skills of an individual is associated with dealing with the risk of cardiac arrest. There is also
identification of a known relationship between filling social roles and adults’ motivation to learn. The author assumes that high task value and self-efficacy will result in learning of the necessary skills. It is also known that the completion of CPR training will increase both CPR knowledge and self-efficacy. The problem of basic resuscitation has shown a mismatch in confidence, skill, and poor retention for decades throughout the literature. It is stated in this study that there is a discrepancy between self-efficacy and the ability to perform CPR has made suggestions about a correlation with a following possible suboptimal incentive to learn CPR. Obtaining self-efficacy for CPR may be an easier task to obtain, but increasing the task value to a high level may be difficult. Self-directed learning also has an important role in adult learning. The learning of new skills is greater when presented in familiar context, and the greater the association with a real life situation that a participant may experience will increase his/her motivation to learn. CPR literature has suggested that CPR skill retention can be improved by having CPR training based on cardiac arrest scenarios appropriate to the course participant’s place of work, which gives relevance to CPR training for that individual.
Virtual Training

Virtual Reality in Education

As stated by Alper, Hollerer, Kuchera-Morin, and Forbes (2010) 3D displays are becoming more ubiquitous within our society. Their study helps to provide possible uses for 3D stereoscopic technology as well as a few others. It had two main focuses for evaluation which were the investigation of viability of stereoscopic depth that could replace augments highlighting with 2D graphing layouts as static visual cues, and to investigate how 3D layout can be used to take advantage of stereoscopic in conventional ways. 3D imaging or visualization is slowly becoming a prominent feature of our society. The use of virtual reality has played a key role in this development.

Hauptman (2010) has managed to relate the enhancement of spatial thinking with virtual spaces to the further development of education. In his study he asked the question to what extent the technology of virtual reality can help students acquire proficiency in geometry that will help them cope with difficulties of mentally recreating geometrical objects and gaining an appropriate understanding of the object. His answer was to provide something that would advance the spatial thinking of students using 3D software. The software chosen for use was Virtual Spaces 1.0. Two questions that the author answered were the following: Is it possible to advance spatial thinking by employing Virtual Spaces 1.0, and to what extent does the addition of self-regulating questions (SRQ)? An experimental treatment design was conducted to assist in the answering of these questions, and the design would be split into four groups. Group 1 n= 52, practiced with Virtual Spaces 1.0 and SRQ. Group 2 n= 52, practiced with the Virtual Spaces 1.0 only. Group 3 n=45, used booklets but with SRQ, and group 4 n=45, used booklets only.
The participants for the study was composed of 213 tenth grade students, and 194 accepted due to them being accustom to using a personal computer (PC). Independent variables were achievements on Spatial – Visual Reasoning test of the Aptitude Profile Series – Education (APTS-E) and Vandenberg and Kuse Mental Rotation (MRT) test. Dependent variables were defined as spatial thinking in nonverbal dimension measured by MRT test, and verbal dimension measured by APTS-E. Data analysis was conducted using SPSS 9.0 using the one directional ANOVA to collect pretest data, and MANOVA was performed with repeated measures over time. Additionally a post hoc analysis (LSD test) was performed to identify the variations in achievement among the groups. The results indicated that the use of virtual space 1.0 did provide some benefits, but there was little difference between groups 1 and 2.

Similar the educational properties of virtual reality were also demonstrated in a study testing the effects of educational strategies on comprehension of a genomic concept by Kaphingst et al. (2009). In this study the authors also wanted to find a better way to identify complex abstract concepts related to genomic research. The author identified possible mediating variables related to increase in motivation, greater ability, and deeper processing. The design study was composed of two groups pertaining to active virtual and didactic virtual learning modes. The sample size was composed of 156 participants between the ages of 18 and 40. Education interventions were structured around five questions presented in the same order that were related to genomic diseases. Dependent variables between the two groups were recalling of memory, whether participants could apply then information, mental model, elaboration, motivation, attention/interest, interest and perceived difficulty, enjoyment of the virtual world, and virtual world rating. These
dependent variables were measured by the use of agree/disagree questions and seven point Likert scale rating, post-test, and a seven point response scale. Analysis was performed with SAS version 8 for windows, and descriptive statistics were examined for all variables. One way ANOVA test was used to examine differences by learning modes with a significance of p<0.05. Linear regression was also used to examine mediation and effect of modification of tested associations. In this case the results indicated higher learning in the group pertaining to didactic learning rather than active, and concluding that there is also a need of further investigation to examine the mediating pathways to determine different learning outcomes.

Virtual reality is not simply limited to traditional mental classroom education. It can also be used in the learning of physical task, which Patel et al. (2006) demonstrates in their study. The effects of fully immersive virtual reality on learning physical tasks are being investigated by using Tai Chi training. The design of the study was to compare differences between immersive virtual reality and video to isolate the effect of immersion. Twenty six undergraduate participants of even gender (13 male and 13 female) were tested under two conditions. Condition 1 pertained to video training with seven males and six female participants. Condition 2 included immersive virtual training with six male and seven female participants. Both participant groups were being presented with some instruction. Group 1 used a traditional video training approach, while group 2 actually reproduced movements based on seeing a virtual avatar. Observations where done by two independent reviewers which provided interrater reliability. When the two observers scores where averaged there was a Cronbach’s alpha=0.55, and in single learning measures the Cronbach’s alpha =0.98. Participants
movement were rated into 13 categories using a seven point Likert scale with 8 questions describing the steps of the Tai chi move, and two describing overall form. The author also rated the participants overall knowledge of tai chi and overall performance on a five point Likert scale, and participants coordination. The results of this study indicated that participants felt higher social and task presence in the virtual setting, as well as performing higher in every category when compared to video training.

**Attitudes Towards Virtual Reality**

One goal of using virtual reality as a training or educational mechanism is to ensure user comfort to assist the illusion of immersion. Virtual Reality has become an extremely popular topic over the last few years, and its applications are only continuing to grow. The sudden explosion of interest in this new and exciting area has prompted many researchers to attempt to gain a better understanding of the benefits of virtual reality, and how it is perceived by the user.

An investigation of learners’ attitudes toward virtual reality learning environments (VRLE) was conducted by Hsiu-Mei Huang, Ulrich Rauch, and Shu-Sheng Liaw (2010). Their study was based on a constructivist approach, which requires learners to take active roles in their learning. There is mention within the study referring to the use of VLREs successfully being integrated as educational applications. There also is a minor discussion devoted to obtaining the feeling of immersion for a classroom of students, and other complications that individuals may face such as motion sickness or fatigue from true immersion. However, learners using computer systems to provide them with an immersive into VRLE are less likely to experience negative side effects. Having the negative side effects reduced or adverted, the authors states that there is a need for a
sound theoretical framework and instructional principles to assist in the development of VLREs as educational tools. They proposed to explore how a constructivist principle can be used in the construction of VRLEs. Their notion of development was derived from four key design principles that governed the creation of VRLEs based on design and building educational applications. These are the usability of the virtual reality interface design, educators’ skill level required to design a virtual course, simulated world believability, and the cost effectiveness in the course design. Two case studies were provided to better understand the use of VRLEs in education. The theory of constructivism puts emphasis on the development of a learner’s abilities in solving a real life problem by associating a learner’s knowledge based on active experience. This approach allows for the learner build meaningful knowledge based on individual experiences, and as a result improving his or her skills through realistic practice. The authors included situated learning, role playing, cooperative/collaborative learning, problem-based training, and creative learning as five key components in designing VRLEs based on a constructivist approach. These components are essential in the development of both case studies. Case study one was a web-based 3D virtual reality interactive learning system that was designed for undergraduate medical students to better understand the human body. The design was composed of three parts which were website design, web server setup, and data base setup. Java script was used in the web design, and applications such as Autodesk 3DMax, VR4MAX were used to develop the 3D course contents. Three factors, intuitive interaction, sense of physical imagination, and the feeling of immersion were expressed as being critical for a virtual reality application. There was also reference to the characteristics that virtual reality
applications should have, and these are natural engagement/interaction, natural expression of actions, realistic feedback, and navigation and orientation support. The author uses these components to develop two hypotheses based on immersion, interaction, and imagination. The first hypothesis states that with increased immersion, interaction, and imagination provided by the virtual reality environment, the motivation of the environment increases. The second hypothesis states that with increased immersion, interaction, and imagination provided by the virtual reality environment, the problem-solving capability of environments increases. The participants were a total of 190 university students that were surveyed to evaluate their attitudes towards the virtual reality learning environments. During this time students were allowed to use the system anytime for a period of one month, after that they were to answer a 16 question questionnaire to explore their understanding of the VRLEs. The final study group for analysis was composed of 167 students. Measurements were based on interaction, immersion, imagination, motivation, problem-solving capability, collaborative learning, and intention to use with dependent variables motivation and enhanced problem-solving capability. The major result from the case one study hypothesis one concluded that immersion, interaction, and imagination were three predictors and immersion had more contribution than the other two on motivation. As for hypothesis two immersion, interaction, and imagination were considered predictors of problem-solving capability, and interaction had a more prevalent role than the others as a predictor. Case study two’s design was based on a collaborative virtual reality learning environment for medical education using a Java based program named 3D Human Organ Learning System (3D-HOLS). The system contains two modes which are single user self-learning, and
collaborative learning mode. The collaborative learning mode allowed multiple users to have interactions, practices, and discussions in a virtual space. This study also contained two hypotheses which were hypothesis three and four. Hypothesis three was based on the three key factors interaction, immersion, and imagination, and it that those factors will have a positive impact on collaborative learning. While hypothesis four stats that there is a positive correlation between collaborative learning and students’ behavioral intention to the 3D-HOLS system. Participants in this study were 76 students (48 males and 28 females) from the school of Medicine, school of Pharmacy, college of Chinese Medicine, and the college of Health Care that answered a 25 question questionnaire related to interaction, imagination, immersion, collaborative learning, and intention to use the system. Here the dependent variables were collaborative learning, and intention to use the system. Results concluded that all three factors in hypothesis three were predictors for collaborative learning, and hypothesis four predicted that collaborative learning can predict the intention to use the virtual learning system.

As a result of these two case studies. The authors refer to the issue of properly developing virtual environments and state that the failure to build proper VRLEs may fail to meet learners’ needs if the activities and task are designed inappropriately, eventually effecting the user’s attitude based on the three key components interaction, immersion, and imagination. VRLEs promote learning through environment interaction, problem solving to promote creativity, learner motivation, and as a scaffolding tool for learner to learn.
Virtual Simulation/Environment

Virtual simulations and environments are quickly becoming a means for cheap testing and training through means of repetitive use and ease of adaptability. Virtual environments such as in game and networking such as World of Warcraft, and Second Life can immerse users into believable 3D environments. These are called networked virtual environments (net-VE), and they allow people to interact with one another through a virtual communication (Gupta, Demers, Gehrke, Unterbrunner, White, 2009). As the technology becomes more sophisticated virtual communication and 3D gaming or training has taken on a completely different meaning.

Creutzfeldt, Hedman, Medin, and Heinriches (2010) view the concept of exploring virtual worlds for scenario based repeated team training of CPR in medical students. This study identifies the uses of massively multiplayer virtual worlds as a tool to teach and train medical students in the practices of team based CPR. Participants that participated in this study were 12 medical students that were placed in teams of 3. Variables that were tested here were done by use of a questionnaire that allowed the students to provide a reflection of their experience. The variables were related to 4 CPR scenarios that measured self-efficacy, concentration, mental strain, and knowledge. Modes of engagement and copy strategies were also observed. Also the study included paramedic and non-paramedic statistical analysis. The author hypothesizes that the virtual world will influence self-efficacy, concentration, and mental strain in the medical students as well as enhancing retention of knowledge. Statistical differences were calculated using the Mann-Whitney U test or Students t-test. Additional statistical test included Shapiro Wilk test, ANOVA, chi-squared, and Fisher exact test. The study
concluded that the use of virtual world did make improvements to the medical students’ self-efficacy, concentration, and mental strain (variable) in the medical students as well as enhancing retention of knowledge.

In the previous study by Creutzfeldt, Hedman, Medin, and Heinriches (2010) some students stated that it would be a good idea to have an actual manikin to perform the CPR procedure on. That brings into existence of virtual worlds together with real objects, which can be referred as a mixed reality environment. Dean et al., (2008) addresses some of the challenges of scenario design in a mixed reality environment. The authors’ design is based on the Infantry Immersive Trainer (ITT), which is a mixed reality training platform for the Marines. The challenges were composed of training objective linkage, scenario control, virtual and real interactions, and virtual indoors versus virtual outdoors. These challenges require the coordination of virtual space and physical space, maintaining the integrity of perception, and maintaining the integrity of the interaction between the marine and the virtual environment or window. Additionally some of these same concepts and challenges apply to the development of 3D virtual trainers.

3D trainers are being used as a tool to prepare first responders in many extreme situations. One example is elaborated on in the study by Wikerson et al., (2008) which focuses on the use of immersive simulation for training first responders for mass casualty incidents. The author used 12 participants in virtual simulations to determine the possible uses of virtual reality in first responder mass casualty training. This virtual simulation was used to assist responders in identifying errors that may cause significant medical implications such as failure to adhere to triage protocols, poor interagency, interagency
and scene to hospital communications, and failure to recognize both static and dynamic hazards. The authors explored the utility of immersive virtual reality simulation for training first responders in a terrorist disaster scenario. The following research questions were asked. Does immersive virtual reality simulation technology provide a realistic training challenge for even highly experienced first responders? Do first responders find the simulation to be believable and convincing? Does it induce stress and anxiety similar to real situations the providers had experienced previously? Do participants consider immersive virtual reality simulation to be a useful adjunct to their prior, traditional training? Does expert review of learner performance identify areas of performance that need improvement? To answer these question participants experienced immersive virtual reality using a cave automatic virtual environment (CAVE). The virtual scenario here was a terrorist attack during a sporting event. While in the simulation participants actions were compared to a pre-defined checklist of decisions, and he or she was recorded during the scenario. The data analysis of event was categorized under “done”, “not done”, “done well”, or “needs improvement” for each participant. Result of this study shows that use of the remarkable flexibility of virtual environments can be used to reproduce effective hazardous training environments with little effort, making virtual reality a useful tool in first responder training.

Similarly another first responder article by Vincent, Sherstyuk, Burgess, and Connolly (2008) researches the teaching of mass casualty triage skills using immersive three-dimensional virtual reality. The authors demonstrate the potential advantages of the use of virtual reality training when compared to more traditional training methods. Participants of this study were 24 medical students. These participants were taught the
principles related to triage skills using podcast, then later with training in a virtual environment. One way ANOVA analysis was used to examine the data of 20 of the 24 participants. Result indicated that 24 students scored above 85% on didactic test and virtual reality exercises, and there were also improvements in the areas of self-efficacy, confidence, and triage which somewhat mimic the result of Wikerson et al., (2008).

Reviewed literature suggests that there is a need to identify better ways to improve CPR performance, retention, and attitude, and virtual reality in combination with CPR may provide a possible solution to an ever-growing issue. This study’s formulation arises from a need that has plagued the resuscitation community around the world for decades. Literature studies have continuously shown varying results with CPR in retention, attitude, training, and adequate performance. There has also been a push to integrate technology into CPR to assist in performance and training with a goal of reducing the complexity of the CPR process. Applications such as video, cell phones, self-instruction guides, etc. have been applied to the area of CPR to support technological innovation of training (Arntz, 2011; Lynch, et al., 2005). Therefore, this study implements a mixed reality simulations involving both CPR and virtual reality that adds to the technological knowledge base of useable tools for CPR training in the efforts to improve CPR skills and experiences.
CHAPTER 3
METHODOLOGY

This research study has contributed to the area of technological innovation for CPR training. The design called for the integration of both CPR and virtual reality in the development of a mixed reality environment to simulate emergency out-of-hospital cardiac arrest situations. The purpose of this research study was to develop a mixed reality simulation to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. The questions that are addressed are:

- How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods?
- How does the use of virtual reality environments for CPR training effect performance compared to traditional training?
- What are the trainees’ attitudes towards virtual training compared to the traditional classroom training?
- What effect does time have on the retention of CPR participants between the control and treatment groups?

Course and Participants

The course used in this study is a certified American Heart Association basic life support course for CPR and AED training. The title of the course is American Heart
Association – Basic Care Life Support for Healthcare Providers with AED. The course communicates knowledge and training concerning CPR practices, current resuscitation guidelines, and AED usage. This course reflects the new resuscitation guidelines adopted in 2010. These guidelines presented changes in the CPR procedure such as eliminating the look listen feel component, chest compression rate and depth, and more (Field, et al., 2010). Participants in this course are usually associated with healthcare including nurse, respiratory therapist, and other medical staff that are expected to adhere to new guidelines to acquire newly revised CPR and AED skill sets. This study’s participants were composed of pre-nursing students, under the School of Nursing curriculum who have little to no experience with CPR. All students also had aspiration of obtaining a healthcare related career. A total of 81 students were used to conduct this study. Students were divided into two studies which included a pilot study, and main study. Both studies were also further divided into a control and treatment group to provide comparisons between groups during each study.

**Research Design**

This interdisciplinary project focused on using stereoscopic display technology and CPR training to reproduce various geometries with depth within the Viscube system to determine the effect on students’ retention of knowledge and performance for CPR as well as evaluating their attitude towards CPR training. This process used multiple software and coding libraries to gain the sensation of experiencing a 3D mixed reality environment that replicates an out-of-hospital cardiac arrest scenario. Coding libraries that were used are OpenGL and SDL which provided libraries to display geometrical objects. SDL mixer is a subcomponent of SDL that was used to produce event handles
and provide sounds sources. The coding language for this research was primarily done using C++, which is an object oriented programming language. Other software or libraries that were used in the creation of the CPR training simulation was Blender and FreeVR. Hardware used in this study included a Linux machine, the Viscube C4-SX Multi-Screen Immersive 3D display system, and a fogger machine model FM-1000.

The design of this project focused on retention of knowledge, performance, and attitude during CPR training. It was divided into two phases, and two groups for each phase, which are the control group and treatment group. Each group was composed of pre-nursing students that volunteered for the study. Evaluations were performed on each group using surveys, performance checklists, and routine testing material to gather data from each student participating in the control or treatment group. Phases of the study were divided into a pilot study and a main study, and the pilot study was used to test and improve evaluations and procedure for the later main study.

**Pilot Study**

The pilot study served as a foundation for development in this study to interpret and understand the influence of virtual reality during CPR training. This study had a total of 40 volunteer students that were divided into control and treatment groups during the summer semester. These participants were used to compare the application and effects of using virtual reality with no distractions. Virtual enhancements were limited to only providing a visual representation of the environment that the participants would be expected to perform CPR. Comparisons were made between an initial testing period and a four week later retesting period. Participants were divided into a control group of 27 participants and a treatment group of 13 participants to identify whether virtually
enhanced trained participants would perform as well as traditionally trained participants with only visually stimulating elements introduced.

**Control Group.** The control group consisted of 27 volunteer pre-nursing students with little to no CPR experience. Data collected from the control group was based on traditional CPR training with no intervention being used. Traditional training followed the 2010 resuscitation guidelines for healthcare providers set in place by the AHA. Traditionally used AHA approved test were given during the course and four weeks after initial testing to measure retention of the participants. For this research study, performance assessments pertaining to the adult CPR training procedure were recorded for each individual. All theoretical emergency situations were introduced by the CPR instructor. Participants had to mentally imagine the emergency, and react accordingly. Each participant experienced approximately 2 minutes of performing adult CPR skill training. A survey was then used to gauge participants’ CPR experience, attitude pertaining to CPR self-efficacy, and attitude towards the CPR course.

**Treatment Group.** The treatment group consisted of 13 pre-nursing students with little to no CPR experience. Data collected form the treatment group was based on the combination of using traditional CPR and the addition of a 3D virtual reality simulation. Virtual reality was used in combination with mannequins traditionally used during CPR training to develop a mixed reality environment to replicate an out-of-hospital cardiac arrest emergency to enhance the CPR training experience. Participants were placed in the role of a bystander first responder containing basic healthcare knowledge relevant to a beginning pre-nursing student. The training followed the 2010 resuscitation guidelines for healthcare providers set in place by the AHA. Traditionally
used AHA approved test were given during the course and four weeks after the initial testing to measure retention of the participants. For this research study, performance assessments pertaining to the adult CPR training procedure were recorded for each individual. Participants experienced visual representation of a virtual environment simulating an out-of-hospital cardiac arrest scenario with no other distractions. The emergency environment’s situation was visualized as 3D models using the Viscube system with no additional effects or distractions; therefore, not requiring participants to mentally imagine the emergency situation. Each participant experienced approximately 2 minutes of adult CPR skill training. The participants experienced no instructor intervention during the out-of-hospital cardiac arrest event. If participants failed to perform adequate CPR or failed to pass the adult CPR performance checks requirements; the instructor relayed corrections needed after the participant had completed at least 2 minutes in the mixed reality simulation. Upon the completion of tests a survey was used to gauge participants’ CPR experience, attitude pertaining to CPR self-efficacy, attitude towards the CPR course, and attitude towards the virtual training.

Procedural measurements used during the pilot study reflected the use of t-test and statistical descriptives to formulate a conclusive research procedure. T-test allowed for the comparison of group means with no more than two independent groups or time periods with participants. Each group or time period contained one independent variable (IV) and one dependent variable (DV). The groups were divided into control and treatment groups with two time periods. Time periods consisted of an initial testing and a four week later retesting to gather the needed data for the study. This study’s time period evaluations employed the use of repeated measures t-test to detect differences that
occurred within the same group over time. The detection of differences between groups at a specific time period required the use of independent t-test. The use of descriptive statistics provided additional information such as frequency reports, means, minimum and maximum values, and standard deviations to assist in data interpretation of participant’s knowledge, performance, and attitude.

Unfortunately, testing comparisons were limited to the initial testing period between groups and only the treatment group was allowed to undergo repeated test measures due to a low return rate for the control group. The pilot study identified deficiencies within the experimental design that were later adjusted during the main portion of this study. As a preliminary measure this study allowed for the use and evaluation of tools such as CPR knowledge test methods, performance checks and video analysis, and attitude survey administration. It provided reference to adjusting the time duration between initial and retesting periods to improve the study’s procedure as well as maintaining the integrity of the visual effects of the virtual environment. Other improvements also provided adjustments for testing procedure, performance evaluation and feedback, and the identification of extreme values such as outliers due to participant variability.

**Main Study**

The main portion of this study was conducted during the Fall semester using a total of 41 volunteer participants. The participants were divided into two groups with a control group of 19 participants and a treatment group of 22 participants. Adjustments determined from data collected during the pilot study included modifications to time duration of test and retest periods, testing procedure, performance evaluation and
feedback, outlier identification, and the introduction of both visual and auditory distractions as virtual training enhancement features. Test feedback from the previous procedure led to the decision of using the same test with minor augmentation for testing and retesting periods, as well as taking into account feedback given by the instructor after each testing instance and participants’ results variability. Testing and retesting periods for each group followed an analysis of variance (ANOVA) design instead of a t-test design, in which each group was initially tested, retested one week later, and retested four weeks after the first retesting period. All testing periods included the assessment of knowledge base test, performance checks and video analysis, and attitude surveying.

Procedural measurements used during the main study reflected the use of ANOVA, t-test, and statistical descriptives to formulate conclusions gained from data collected during this research study. ANOVA allowed for the comparison of group means with two independent groups at three different time periods. Each group contained two IVs group and time, and one DV that was dependent on the criteria being measured. The groups were divided into control and treatment groups with three time periods. Time periods consisted of an initial testing, one week later retesting, and a four week later retesting after the first retesting period to gather the needed data for the study. This study’s time period evaluations employed the use of repeated measures ANOVA to detect differences that occurred within the same group over time. The detection of differences between groups over time required the use of Mixed-Design ANOVA with time as a within factor and group as a between factor. Additionally independent t-tests were used to provide information between group differences at a specific point in time. Furthermore the use of descriptive statistics provided additional information such as
frequency reports, means, minimum and maximum values, and standard deviations to assist in data interpretation of participant’s knowledge, performance, and attitude.

**Control Group.** The control group consisted of 19 volunteer pre-nursing students with little to no CPR experience. Data collected from the control group was based on traditional CPR training with no intervention being used. Traditional training followed 2010 resuscitation guidelines for healthcare providers set in place by the AHA. Traditionally used AHA approved test were given during the course and one week after the course as retesting period one, and four weeks after retesting period one to measure retention of the participants. For this research study, performance assessments pertaining to the adult CPR training procedure were recorded for each individual and instructor feedback was provided after each testing period. All theoretical emergency situations were introduced by the CPR instructor. Participants had to mentally imagine the emergency, and react accordingly. Each participant experienced approximately 2 minutes of performing adult CPR skill training. A survey was then used to gauge participants’ CPR experience, attitude pertaining to CPR self-efficacy, and attitude towards the CPR course.

**Treatment Group.** The treatment group consisted of 22 volunteer pre-nursing students with little to no CPR experience. Data collected form the treatment group was based on the combination of using traditional CPR and the addition of a 3D virtual reality simulation. Virtual reality was used in combination with mannequins traditionally used during CPR training to develop a mixed reality environment to replicate an out-of-hospital cardiac arrest emergency to enhance the CPR training experience. Participants were placed in the role of a bystander first responder containing basic healthcare
knowledge relevant to a beginning pre-nursing student. The training followed 2010 resuscitation guidelines for healthcare providers set in place by the AHA. Traditionally used AHA approved test were given during the course and one week after the course as retesting period one, and four weeks after retesting period one as retesting period two to measure retention of the participants. For this research study, performance assessments pertaining to the adult CPR training procedure were recorded for each individual and instructor feedback was provided after each testing period. Participants experienced visual and auditory distractions that are expected of the specified out-of-hospital cardiac arrest scenario. Emergency environments situations were visualized as 3D models using the Viscube system with a mixture of sound and visual effects; not requiring participants to mentally imagine the emergency situation. Each participant experienced approximately 2 minutes of adult CPR skill training. The participants experienced no instructor intervention during the out-of-hospital cardiac arrest event, but they were given corrective feedback on mistakes made. If participants fail to perform adequate CPR or fail to pass the adult CPR performance checks requirements; the instructor relayed corrections needed after the participant had completed at least 2 minutes in the mixed reality simulation. Upon the completion of test a survey was used to gauge participants’ CPR experience, attitude pertaining to CPR self-efficacy, attitude towards the CPR course, and attitude towards the virtual training.

**Assessments.** Retention has been a common issue of CPR. There exist literature studies that attempt to explain CPR skill retention and the degradation of CPR knowledge over time (Mahony, Griffiths, Larsen, & Powell, 2008; Woollard, et al., 2004). In this study retention was evaluated differently compared to some of the previous studies. The
knowledge of the participants was gauged by using a traditional testing exam approved by the AHA. Participants were given examinations as a standard requirement for completion of the course. Participants’ names were coded to keep track of each individual score. During the pilot study participants were recalled four weeks later to retake an equivalent AHA approved version of the CPR knowledge based test. These students were initially tested using a CPR knowledge based exam version A, and later tested using version B (appendix). The pilot study’s retention of CPR knowledge test led to the following improvements to be made during the main study. Improvements that were made included the decision to use only one version of the AHA approved exams. The CPR knowledge test, exam version A, was used during testing and retesting periods during the main study. Five additional questions from the CPR exam version B were placed above all questions from CPR exam version A during each retesting periods. These questions were used to make each exam’s first page vary in appearance from its predecessor with each retesting period containing different questions on the first page of the test, and all questions that followed were identical to the CPR exam version A. Test versions were also renamed by testing period with initial, retesting period one, and retesting period two with versions A, B, and C respectively (appendix). This method was used to make the test appear as if they were different test. The only portion of the exams that was scored was the identical questions that were on the CPR exam version A. Participants’ knowledge was retested during two separate retesting periods one week following initial testing, and four weeks after the first retesting period to determine whether there was a change in CPR knowledge. These tests were used to further understand the time frame in which knowledge is retained by each individual. The data
was analyzed and compared to determine if there were any signs of change between the scores of each participant.

The performance evaluation is an important part of CPR training, and practices vary among different resuscitation organizations throughout many communities (Parnell & Larsen, 2007). In this study performance was evaluated to compare the adult CPR process among each group. Evaluations were consistent with the newly adopted 2010 resuscitation guidelines, and scored using an Adult CPR performance checklist. The checklist was developed from the approved AHA standard checklist used during the CPR training course. The original checklist included six items to evaluate the adult CPR procedure. The performance checklist used during this study reflected on all six items used by the AHA standard performance checklist. These six items were expanded into an Adult performance check list that was composed of 11 sections with 33 individual procedural checks that reflected the six categorical checks used in the AHA approved standard performance checks. Additionally, each check list could now be measured with a maximum score of 50 points. Point distribution was based on importance of the 2010 AHA CPR guidelines. Further review of the checklist was done by a CPR professional and AHA course instructor, and the use of authorized AHA 2010 performance checks guidelines to be properly refined to best represent an Adult CPR performance checklist. After gaining the instructors approval, the check list was then used to measure each participant during an approximate two minutes of training. Participants were then checked off and earned points as they correctly performed the Adult CPR procedure, and the instructor evaluated up to five complete cycles within the two minute time frame in both control and treatment groups. All performance checks were performed by the same
certified instructor to reduce bias that may occur between performance checks. The instructor was also able to place comments indicating each participant’s performance, and corrective feedback was given after each testing period. Recorded video was also combined with performance checks and later compared to the instructor’s checks to ensure accuracy. The video data and performance checks were also used to identify common mistakes between all participants. All data collected relative to performance was analyzed to determine which group performed better over time. It also provided a better insight into comparing theoretical self-imagine emergency situations to a visual and auditory stimulating emergency environment.

Another important issue associated with CPR is attitude. In this study attitude was measured by the use of a survey. The survey was composed to gauge each participant’s CPR experience initially, attitude pertaining to CPR self-efficacy (i.e. confidence, competence), attitude towards the course, and attitude towards virtual training experience. Here it is important to note that both groups will not receive the same survey. Both control and treatment group received similar sections on the survey, but the treatment group had an additional page that collected data on their virtual training experience. This assisted in determining whether virtual training has an effect on training motivation, and also served as a feedback tool to indicate attitude from incorporating virtual training into the CPR training process. Data that was analyzed from surveys used in this research design were used to determine if both groups have relatively equal experience, and also assist in further unraveling the complicated issue of participants’ attitudes towards CPR.
Environment Simulation and Design

Environment simulation and design is a key component in the construction and manipulation of the mixed reality environment for this research. The environment was constructed so that pre-nursing students would have the opportunity to experience an out-of-hospital cardiac arrest. The simulation was designed so that the obligation of producing mental imagery provided by traditional CPR course scenarios could be rendered in 3D to improve the CPR performance skills assessment experience for adult CPR training. The architecture of the environment was based on a basic apartment kitchen scene represented by figure 3.1. The scenario immersed participants in the role of a first responder to the cardiac arrest event without any additional support. In the pilot study the rescuer was faced with only the complication involving the cardiac arrest victim with only the visualization of the virtual environment with no distractions; while in the main study the rescuer was faced with three primary complications involving the cardiac arrest victim, smoke as a visual distraction, and a loud radio as an auditory distraction. The scenario’s story was based on a victim experiencing chest pains in the kitchen area of an apartment, and suddenly collapsing. Participants were expected to perform Adult CPR to resuscitate the victim. Distractions were used to measure the participants’ awareness of their environment, and to determine if the virtual environment had any influence on performance.
Participant performance assessments were conducted for approximately a two
minute time period. A fog machine was used to provide a thin layer of smoke as a visual
distraction immediately upon entering the scene. A loud radio was provided an auditory
distraction, and was activated immediately upon entering the scene. The smoke was used
as the first indication of possible danger, and observational notes were made for each
participant to gauge their awareness of their surroundings. Other notes were taken in
addition to performance checks to identify pauses in compression due to distractions in
the mixed reality environment.

During the simulations participants were not allowed to see or hear other
participants performing CPR to reduce external influence. Students were taken into the
simulation one by one. Each individual was introduced to the virtual training separately,
and dismissed to return to the classroom after experiencing the training scenario. Those
individuals were placed away from students that had not attended the virtual
enhancement training sessions to reduce external influence factors. This cycle was
repeated until all participating students had experienced the virtual training portion of the
course.
Software/Libraries

**OpenGL.** In this study OpenGL was used to control display settings such as lighting, shading, texturing, and color. It also was used to construct geometrical models of the simulation environment. OpenGL has the capabilities to generate graphical displays and is a free open source cross platform API that allows the user to code 2D and 3D computer graphics. It’s a great program that is useable on multiple systems such as Windows, Linux, etc. therefore gaining its reputation as a cross platform API. OpenGL incorporates low-level procedures; requiring the user to determine the proper methods to render a scene or image. This can be both a pro and con when considering using this API. It provides a great deal of freedom, but may require the user to become knowledgeable of the graphics pipeline (SGI, 2013). OpenGL was the primary source that allowed for the display of multiple objects within the virtual scene.

**SDL.** SDL represents Simple DirectMedia Layer. SDL is a cross platform multimedia library that provides low level access to many functions such as audio, keyboard, mouse, joystick, etc. It also can be used in conjunction with OpenGL to develop 3D or 2D geometric objects. SDL is written using C coding but is able to work with many other languages including C++ (SDL Simple DirectMedia Layer, 2012). In this study SDL version 1.2 had two functions. SDL was used to read in textures from UV files created using Blender, and controlling events. SDL mixer is a sub portion of SDL. It was used to control sound events such as the radio in the out-of-hospital cardiac arrest emergency.

**Blender.** Blender’s primary role in this study was related to the construction of geometry. Blender is a free open source, open architecture, integrated application that
allows users to develop a variety of 2D or 3D content. It provides modeling, texturing, lighting, animation, and video post-processing functionality. Blender is cross platform 3D graphics application that originally was developed to appeal to media professionals and artist (Blender, 2012). The entire virtual scene was created using the Blender software. Models were built then converted into .obj files to be exported useable format. UV mapping was used to test and design models textures that would be later read into the designated portion of the code. Models created using Blender are represented by figures 3.2 and figure 3.3.
Figure 3.2 Blender Models - Show models that were built to complete the apartment kitchen scene. Left: Models; Right: UV mapping and texturing of models
C++ Programming Language. C++ is known as an object-oriented programming language. It gives the user the ability to develop new classes objects, structures, etc. while programming. C++ has been around for some time now, and is widely used in many applications such as gaming. It has also managed to influence other programming languages. It is more of an intermediate language which gives access to both high and low level language features, and is one of the most popular programming languages. C++ is the primary language used in the code in this study. It was used to construct structures and classes to manipulate read in geometrical data to be interpreted by SDL, OpenGL, and FreeVR.

FreeVR. FreeVR can be used with different graphic libraries, but in this study it was used in conjunction with OpenGL to develop 3D virtual environments (Sherman, 2012). FreeVR is an open source virtual reality interface/integration library. FreeVR’s design is capable of working with a variety of input output hardware devices. Its applications consist of running virtual reality systems, and one of its functions is to provide a library source which reduces the complication of working with 3D virtual environment construction. FreeVR provides an array of callback functions when
combined with OpenGL; FreeVR communication with input devices such as projectors. to properly render 3D graphics. In this particular case FreeVR assisted in control of the projectors associated with a 4 wall Viscube set up to generate 3D imagery.

**Hardware**

Visualization hardware mainly consisted of a Linux machine powered with Nvidia Quadro graphics, and the Viscube C4-SX by Visbox. The Visbox is a 4 walled structure composed of a floor, front, and two sides that use a system of eight digital projectors to project 3D imagery around the user at a resolution of 1400 by 1050 per screen. Other peripheral equipment included Infitec eye wear, and Intersense tracking with a IS-900 micro track head tracker to promote a further degree of 3D immersion and control (Visbox, 2013). The Viscube is the primary source that assisted in providing a visual output to the user. Other hardware that provided a more environmentally focused aesthetic appeal was the use of a fogger machine. The fogger machine model FM-1000 was used to enhance the visual effects of the mixed reality environment by producing light smoke. Additionally other software libraries had to be used to generate the visual environment that was displayed using the Viscube system. Software packages and libraries that were used are Blender, OpenGL, Simple Directmedia Layer (SDL), and FreeVR. Figures 3.4 show a varying intensity of smoke when combined into the mixed reality environment. With the proper use of the fogger a lightly filled smoke environment can be created that will allow for the CPR procedure to be performed, but not deter participants from performing CPR.
In the case of using haptic devices for CPR, haptic are more based on force-based impedance to sense physical or tactile feedback from users. Particularly in this research situation, in the attempt to remain as consistent with the traditional classroom associated training as possible; the haptic device used was an upper half torso mannequin. Typically these mannequins contain some sort of sensor to measure the force applied and displacements. The newer guidelines introduced after 2005 and 2010 require a greater compression depth to be applied to the chest during CPR, which in turn generates more force and pressure that haptic devices undergo. The model type that used was pre-programmed to meet the current specifications of 2010 American Heart Association guidelines. The models used were Prestan Professional Training Mannequin models PP-AM-100M or PP-AM-400M. The haptics of these models are forced based, and uses a system of built-in LED light sources to indicate proper compression depth and rate. Performance feedback was recognized by the sequence of lights that were illuminated simultaneously, and each individual LED relates to compression depth or rate. Additionally, there was be a clicking sound as an auditory response when applying the

Figure 3.4 Smoke Visualization - Shows the varying intensity of smoke produce by the fogger machine. Left: Light smoke filled environment; Right: Heavily smoke filled environment
correct amount of force to gain a predefined compression depth. Figure 3.5 shows the mannequin in both inactivated and activated instances.

![Figure 3.5 CPR Mannequin - Left: Mannequin that is not activated; Right: Mannequin activated by compressions indicated by lights in right shoulder.](image)

**Survey**

The survey was another one of the key instruments in this study. The survey played the crucial role of measuring experience and attitude of the students that participated. The survey was composed of one temporary section experience, and four main sections which were self-efficacy components confidence and competence, course attitude, and attitude towards virtual training. Attitude was measured using a 5 point Likert scale ranging from strongly disagree to strongly agree, and experience statements used a yes and no format to evaluate participant’s experience. Each section had been divided into smaller subsections to gain specific measurements throughout the survey. The experience section was composed of statements related to experience and knowledge of each participant. This section was used to gauge the experience of participants to determine if there were any differences in the participant’s range of experience that would exclude them from the research study. Experience observations were conducted for both the control and treatment group in both the pilot and main study. The attitude
section of the survey had three main sections. These sections were based on self-efficacy, attitude towards the course, and attitude towards virtual training. The self-efficacy component was further divided into subsections that measured confidence and competence. Attitude towards the course and attitude towards virtual training provided attitude measurements on environment influence, course duration, and self-performance. All statements in the survey were categorized into areas such as knowledge, self-performance, environmental influence, duration, willingness and motivation.

This survey went through three phases of refinement, before reaching its final form. The original survey contained a total of 58 statements to evaluate students’ attitude and experience. 10 statements pertaining to the area experience and knowledge, and 48 statements measuring attitude evaluating self-performance, environmental influence, motivation/willingness, and course duration were on the survey. The statements were arranged as follows: 7 confidence, 11 competence, 6 motivation/willingness, and 17 attitude towards course. These statements were further refined by deleting statements that showed redundancy, lesser degree of usefulness, and overlap. After the refinement of the survey, the second draft was developed which now only included 36 CPR related statements with the addition of 7 virtual training statements yielding a total of 43 statements. The survey consisted of the following: 8 experience and knowledge, 7 confidence, 10 competence, 1 willingness, 10 attitude towards course, and 7 virtual reality training statements. Further refinement of this survey was completed after gaining Institutional Review Board permissions to conduct in class CPR testing. The survey was administered to experienced participants that have had BLS training at least once under the new 2010 guidelines. This refinement led to the deletion of the majority of the
statements concerning willingness and motivation, since they showed only a small amount of relation to the study. There were also changes in wording of specific statements to improve clarity.

The final refinement of the survey instrument was based on a content validity rating or ratio (CVR). Previous literature has used similar methods to determine how valid a statement’s or question’s content is in relation to nature of the instrument. The CVR value was determined by referencing material from previous studies (Lawshe, 1975; McKenzie, Wood, Kotecki, Clark, & Brey, 1999). This process required jurors to be selected that were experts in the area of CPR to technically gauge the relation of the statements of the instrument to the nature of the study. Jurors were identified based on their CPR related credentials as experts, and affiliation with the AHA as certified CPR instructors. A total of 8 CPR professionals were solicited as jurors. 5 responded giving a response rate greater than 50%. The individuals were asked to take part in a two phase content validity procedure. This procedure asked members to participate in a two part review including qualitative and quantitative reviews. The actual survey determined by jurors can be seen in detail in the appendix of this study. Also all reviews were conducted using Survey Monkey.

The qualitative review allowed jurors the opportunity to provide feedback using comment boxes. The additional information added to the review letter was the following:

_This portion of the review will be considered phase I. It is a qualitative review that allows reviewers to give feedback and comments to improve the statements and directions, or agree that the statements and directions are adequate. I will attach a sample document of the phase I qualitative review in pdf format in a later email, but the actual survey will direct you to SurveyMonkey via the provided link to take the electronic form of the survey. Please do not complete the pdf copy of the survey; it is only used to allow you to see the survey before going to the electronic version. Each section of the_
survey contains specific directions and will state what each item is attempting to measure. It will also state the grading criteria for the items that I am attempting to measure for that specific section. After the deadline of March 6\textsuperscript{th}, 2013 the second and final phase will be administered for your feedback.

Thank you for considering this request. Please contact me via e-mail, or telephone by March 6\textsuperscript{th}, 2013 if you need any assistance.

This review contained comments from certified CPR professionals that further assisted in eliminating statements that they considered not useful; there was also suggestions for rewording specific statements. The following quantitative phase was commenced shortly after all the jurors completed the qualitative review. The quantitative phased contained revised statements suggested by the jurors during the qualitative phase. It is important to clarify that suggestions during the qualitative section of reviewing were few and minor; this may have been due to the two previous stages of instrument refining. During this quantitative review jurors were expected to rate each statement in the category of essential, useful but no essential, and not necessary. The additional information given to the reviewers was the following:

This portion of the review will be considered phase II. It is quantitative review that allows reviewers to give feedback and comments on the appropriateness of the statement for each section, or agree that the statements essential to study. In this phase reviewers will state whether the statements are among three choices essential, useful but not essential, or not necessary. Essentialness of each statement is based on its relevance or importance to the study. I will attached a sample document of the phase II quantitative review in pdf format in a later email, but the actual survey will direct you to SurveyMonkey via the provided link to take the electronic form of the survey. Please do not complete the pdf copy of the survey; it is only used to allow you to see the survey before going to the electronic version. Each section of the survey contains specific directions and will state what each section is attempting to measure. It will also state the grading criteria for the items that I am attempting to measure for that specific section. After the deadline of March 20\textsuperscript{th}, 2013 the calculation of validation will begin.

Thank you for considering this request. Please contact me via e-mail, or telephone by March 20\textsuperscript{th}, 2013 if you need any assistance.
Essential ratings on the quantitative review allowed for the CVR rating of each statement to be calculated to determine its content validity in relation to the study. The formula used to calculate CVR was

\[ CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \]

In this formulation, CVR represents the content validity ratio \( n_e \) represents the number of jurors indicating “essential”. \( N \) represents the total number of jurors. These values are later compared to a table that indicates the minimum value of content validity ratio needed for the statement to have acceptable content validity. Since there were only 5 juror respondents that responded a validity ratio of 0.99 was needed to indicate good validity. Also it is important to take into consideration that any CVR value greater than 0 but less than 0.99 demonstrates some degree of validity (Lawshe, 1975). Results from the calculation of CVR for each statement on the instrument showed that 26 of the 43 statements reached a CVR of 1.00, which is very reasonable validity according to the previous literature. Two questions concerning experience had to be deleted due to a negative CVR value. The remaining questions had either a CVR value of 0.2 or 0.6 demonstrating some degree of validity, so they were retained on the instrument due to relative importance to the study. A total of 10 questions had a CVR of 0.6 and 5 with a CVR of 0.2. On the completion of the review and calculation of the CVR values the final survey was developed. Table 3.1 shows the final survey instrument with categorized statements and CVR values. Statements that were deleted were “I have personally witnessed out-of-hospital cardiac arrest” and “I have personally witnessed cardiac arrest” due to a CVR value of -0.6.
Table 3.1 Survey Instrument Categorizing - Shows survey instrument statement and categorization of each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Section</th>
<th>Category</th>
<th>CVR value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have personally experienced performing CPR.</td>
<td>Experience</td>
<td>Knowledge</td>
<td>0.6</td>
</tr>
<tr>
<td>I have previously attended a CPR training course.</td>
<td>Experience</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>My last CPR course was before the new 2010 guidelines were introduced.</td>
<td>Experience</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>I have performed CPR in a hospital emergency.</td>
<td>Experience</td>
<td>Knowledge</td>
<td>0.2</td>
</tr>
<tr>
<td>I have performed CPR in an out-of-hospital emergency.</td>
<td>Experience</td>
<td>Knowledge</td>
<td>0.2</td>
</tr>
<tr>
<td>I have had continuous chest compression CPR training</td>
<td>Experience</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>I hesitate to attempt CPR because I do not know how to resuscitate well.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I feel confident that I could perform CPR in a real emergency.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I would probably do more harm than good if I tried to perform CPR in a real emergency.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>0.6</td>
</tr>
<tr>
<td>I feel confident in performing CPR.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>0.6</td>
</tr>
<tr>
<td>I am able to work as a member of a resuscitation (CPR) team.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I am able to work as a leader of a resuscitation (CPR) team.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>0.6</td>
</tr>
<tr>
<td>I hesitate to perform defibrillation, because I am not ready.</td>
<td>Confidence</td>
<td>Self-Performance</td>
<td>0.6</td>
</tr>
<tr>
<td>I think that I need more BLS training to correctly perform CPR.</td>
<td>Competence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I am knowledgeable about the current CPR process and guidelines.</td>
<td>Competence</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>I can recognize cardiac arrest.</td>
<td>Competence</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>I have the skills to effectively perform CPR.</td>
<td>Competence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I am able to perform defibrillation with an AED.</td>
<td>Competence</td>
<td>Self-Performance</td>
<td>1.0</td>
</tr>
<tr>
<td>I am aware of current CPR</td>
<td>Competence</td>
<td>Knowledge</td>
<td>1.0</td>
</tr>
<tr>
<td>Statement</td>
<td>Category</td>
<td>Score</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>I am aware of the effectiveness of bystander CPR.</td>
<td>Competence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I understand the uses of Continuous Chest Compressions CPR.</td>
<td>Competence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I understand the current resuscitation guidelines.</td>
<td>Competence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I am aware of dangers in my environment before initiating CPR.</td>
<td>Competence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I will perform CPR in a dangerous environment.</td>
<td>Motivation/Willingness</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>My last CPR course was too short.</td>
<td>Attitude towards Course</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>This CPR course was too long.</td>
<td>Duration</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>I enjoyed the course.</td>
<td>Interest</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>I feel more prepared after taking this CPR course.</td>
<td>Self-Performance</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>New resuscitation guidelines are difficult to perform during an emergency.</td>
<td>Attitude towards Course</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Resuscitation guidelines simplify CPR medical practice.</td>
<td>Self-Performance</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>I am motivated to attend further courses.</td>
<td>Motivation</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>This course has improved my readiness to perform CPR better than previous courses.</td>
<td>Attitude towards Course</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>The environment helped to improve my CPR performance.</td>
<td>Environmental Influence</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Distractions in the environment affected my CPR performance.</td>
<td>Environmental Influence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Virtual hazards or distractions affected my CPR performance (i.e. smoke, sounds, etc.).</td>
<td>Attitude towards Course</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I felt distracted by sounds while performing CPR in the virtual environment.</td>
<td>Environmental Influence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I felt distracted by visible hazards during virtual training.</td>
<td>Environmental Influence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Sounds or other effects made me nervous or anxious while performing CPR.</td>
<td>Environmental Influence</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>I think that virtual training is more realistic than traditional classroom</td>
<td>Environmental Influence</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>
I feel more prepared for an out-of-hospital cardiac arrest emergency when using virtual training.

I would prefer that all CPR performance skills were done in a virtual environment setting.

<table>
<thead>
<tr>
<th>Question</th>
<th>Attitude towards Course</th>
<th>Self-Performance</th>
<th>Environmental Influence</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel more prepared for an out-of-hospital cardiac arrest emergency</td>
<td>Attitude towards Course</td>
<td>Self-Performance</td>
<td>Environmental Influence</td>
<td>1.0</td>
</tr>
<tr>
<td>when using virtual training.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would prefer that all CPR performance skills were done in a virtual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>environment setting.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Survey Reliability.** Reliability for the survey instrument was determined using an internal consistency reliability approach during the pilot study portion of this study using IBM SPSS. The survey was administered once among the control and treatment groups. Although the survey contains an experience section, it was only used for initial testing purposes to ensure that participants fell within a certain range of experience for this study. It also underwent the vigorous content validity process to ensure that experience related questions were relevant to CPR content training. The final CPR survey version was used for testing and can be found in the appendix. The survey was divided into four sections. Two sections were related to self-efficacy which measured the participants’ level of confidence and competence. The remaining section measured participants’ attitude towards the course and attitude towards the virtual training. Each participant in the study was required to complete the survey instrument; those that did not were dismissed from the study. Cronbach’s alpha is a method used for determining the internal consistency reliability that was used for this study which was calculated using IBM SPSS and is represented by the following equation:

$$\alpha = \frac{K}{K - 1} \left(1 - \frac{\sum_{i=1}^{K} \sigma_{Y_i}^2}{\sigma_X^2}\right)$$

Variables used in the formulation of this equation are used to calculate the Cronbach’s alpha value and the level of reliability. Here the variable K represents the components or number of items measured, where \(X = Y_1 + Y_2 + Y_3 + \cdots + Y_k\). \(\sigma_X^2\), represents the variance.
of the observed total test scores, and $\sigma_i^2$ represents the variance of component $i$ for that current sample of person. To easily categorize the survey, survey statements names were used with the following numbers schemes shown in Table 3.2. This approach assisted in identifying and documenting any items of the survey that required reverse scoring. Each item was subdivided into sections in relevance to Self-Efficacy Confidence, Self-Efficacy Competence, Course Attitude, and Virtual CPR Training.

**Table 3.2 Survey Instrument Reliability Sections** – Shows how the survey tool divided into sections to gain instrument reliability measurements

<table>
<thead>
<tr>
<th>Survey Item Description</th>
<th>Survey Item Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>I hesitate to attempt CPR because I do not know how to resuscitate well.</td>
<td>Self_Efficacy_Confidence_1</td>
</tr>
<tr>
<td>I feel confident that I could perform CPR in a real emergency.</td>
<td>Self_Efficacy_Confidence_2</td>
</tr>
<tr>
<td>I would probably do more harm than good if I tried to perform CPR in a real emergency.</td>
<td>Self_Efficacy_Confidence_3</td>
</tr>
<tr>
<td>I feel confident in performing CPR.</td>
<td>Self_Efficacy_Confidence_4</td>
</tr>
<tr>
<td>I am able to work as a member of a resuscitation (CPR) team.</td>
<td>Self_Efficacy_Confidence_5</td>
</tr>
<tr>
<td>I am able to work as a leader of a resuscitation (CPR) team.</td>
<td>Self_Efficacy_Confidence_6</td>
</tr>
<tr>
<td>I hesitate to perform defibrillation, because I am not ready.</td>
<td>Self_Efficacy_Confidence_7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Survey Item Description</th>
<th>Survey Item Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think that I need more BLS training to correctly perform CPR.</td>
<td>Self_Efficacy_Competence_1</td>
</tr>
<tr>
<td>I am knowledgeable about the current CPR process and guidelines.</td>
<td>Self_Efficacy_Competence_2</td>
</tr>
<tr>
<td>I can recognize cardiac arrest.</td>
<td>Self_Efficacy_Competence_3</td>
</tr>
<tr>
<td>I have the skills to effectively perform CPR.</td>
<td>Self_Efficacy_Competence_4</td>
</tr>
<tr>
<td>I am able to perform defibrillation</td>
<td>Self_Efficacy_Competence_5</td>
</tr>
</tbody>
</table>
with an AED.
I am aware of current CPR guidelines.
I am aware of the effectiveness of bystander CPR.
I understand the uses of Continuous Chest Compression CPR.
I understand the current resuscitation guidelines.
I am aware of dangers in my environment before initiating CPR.

<table>
<thead>
<tr>
<th>Survey Item Description</th>
<th>Course Attitude Survey Item Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will perform CPR in a dangerous environment.</td>
<td>Course_Attitude_Motivation_Willingness_1</td>
</tr>
<tr>
<td>My last CPR course was too short.</td>
<td>Course_Attitude_Duration_1</td>
</tr>
<tr>
<td>This CPR course was too long.</td>
<td>Course_Attitude_Duration_2</td>
</tr>
<tr>
<td>I enjoyed the CPR course.</td>
<td>Course_Attitude_Interest_1</td>
</tr>
<tr>
<td>I feel more prepared after taking this CPR course.</td>
<td>Course_Attitude_Self_Performance_1</td>
</tr>
<tr>
<td>New resuscitation guidelines are difficult to perform during an emergency.</td>
<td>Course_Attitude_Self_Performance_2</td>
</tr>
<tr>
<td>Resuscitation guidelines simplify CPR medical practice.</td>
<td>Course_Attitude_Self_Performance_3</td>
</tr>
<tr>
<td>I am motivated to attend further courses.</td>
<td>Course_Attitude_Interest_2</td>
</tr>
<tr>
<td>This course has improved my readiness to perform CPR better than previous courses.</td>
<td>Course_Attitude_Self_Performance_4</td>
</tr>
<tr>
<td>The environment helped to improve my CPR performance.</td>
<td>Course_Attitude_Environmental_Influence_1</td>
</tr>
<tr>
<td>Distraction in the environment affected my CPR performance.</td>
<td>Course_Attitude_Environmental_Influence_2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Virtual CPR Training Survey Item Description</th>
<th>Virtual CPR Training Survey Item Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual hazards or distractions (i.e. smoke, sounds, etc.) affected my CPR performance.</td>
<td>Virtual_CPR_Training_Environmental_Influence_1</td>
</tr>
<tr>
<td>I felt distracted by sounds while performing CPR in the virtual environment.</td>
<td>Virtual_CPR_Training_Environmental_Influence_2</td>
</tr>
<tr>
<td>I felt distracted by visible hazards (i.e., smoke, etc.) during virtual training.</td>
<td>Virtual_CPR_Training_Environmental_Influence_3</td>
</tr>
<tr>
<td>Sounds or other effects made me</td>
<td>Virtual_CPR_Training_Environmental_Influence_4</td>
</tr>
</tbody>
</table>
nervous or anxious while performing CPR. I think that virtual training is more realistic than traditional classroom training. I feel more prepared for an out-of-hospital cardiac arrest emergency when using virtual training. I would prefer that all CPR performance skills were done in a virtual environment setting.

In calculating the Cronbach’s alpha to determine the level of internal consistency there were some survey items that needed to be reversed scored to properly measure reliability. 12 items were reversed scored using the same 5 point Likert scale, where 5 indicated strongly disagree to 1 indicating strongly agree. The following items were reversed scored are listed in table 3.3. Item Section refers to the section used for reliability analysis, and the survey item refers to the reversed item in relation to each section.

<table>
<thead>
<tr>
<th>Item Section</th>
<th>Survey Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy Confidence</td>
<td>Confidence_1, 3, and 7</td>
</tr>
<tr>
<td>Self-Efficacy Competence</td>
<td>Competence_1</td>
</tr>
<tr>
<td>Course Attitude</td>
<td>Motivation_Willingness_1, Duration_1, Duration_2, Attitude_Self_Performance_2</td>
</tr>
<tr>
<td>Virtual CPR Training</td>
<td>Environmental_Influence_1, 2, 3, and 4</td>
</tr>
</tbody>
</table>

After properly reverse scoring these items each section was thing averaged for each participant, therefore yielding one value for each of the four sections. The four averages were labeled Confidence_Avg, Competence_Avg, Course_Attitude_Avg, and Virtual_Training_Avg. These averages of each section were used in determining the
internal consistency reliability using 13 participants of the treatment group. Although both groups were tested for internal consistency reliability, the treatment group allowed for full use and reliability measurements of the survey instrument. It is important to note that the control also had more than acceptable Cronbach’s alpha results or higher for each section, which was made up of 27 participants. The control group’s results were not used due to the group’s inability to provide measurements for the virtual training portion of the survey, since they lacked the virtual enhancement intervention. The treatment group’s Cronbach’s alpha results for each section of the survey are shown in table 3.4.

<table>
<thead>
<tr>
<th>Survey Section</th>
<th>Cronbach’s Alpha, $\alpha$</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy Confidence</td>
<td>0.914</td>
<td>7</td>
</tr>
<tr>
<td>Self-Efficacy Competence</td>
<td>0.874</td>
<td>10</td>
</tr>
<tr>
<td>Course Attitude</td>
<td>0.731</td>
<td>11</td>
</tr>
<tr>
<td>Virtual CPR Training</td>
<td>0.881</td>
<td>7</td>
</tr>
</tbody>
</table>

Cronbach’s alpha scale for internal consistency has reliability ratings of excellent $\alpha \geq 0.9$, good $0.9 > \alpha \geq 0.8$, acceptable $0.8 > \alpha \geq 0.7$, questionable $0.7 > \alpha \geq 0.6$, poor $0.6 > \alpha \geq 0.5$, and unacceptable $0.5 > \alpha$. From table 3.4 it can be seen that the survey instrument is very reliable containing Cronbach alpha’s with acceptable to excellent reliability ratings.

**Performance Checklist Reliability.** Knowledge base test were routine material to the CPR training course and did not require reliability testing. Other testing material such as the adult performance check list did required reliability testing, even though it was merely an expanded and more detailed form derived from the original course’s AHA approved performance checklist. The Adult performance checklist used in this study was
tested using interrater reliability. Performance checks were performed by a single instructor to have consistency within the ratings of participant performance throughout the study. The instructor that participated in this study performance checks were compared to two other expert instructors to determine the reliability of the performance checklist instrument. Performance assessments were conducted during the instructor’s routine CPR training courses using 30 participants equally divided into two courses prior to the pilot study. Each instructor rated the same participant’s performance, and reliability analysis determined using Cronbach’s Alpha and IBM SPSS statistical software in each course. The decision to use at least two courses and two instructors was due to the history of instructor variability which is discussed in the literature of this dissertation. To ensure that there was little variability as possible between performance instrument’s ratings, interrater reliability was measured in both cases. The instructor of the study was be referred to as the instructor, and instructors used in the first and second comparisons were be referred to as instructor 1 and instructor 2 in respect to the course 1 and course 2. During course 1, 15 participants’ performance results were compared between the instructor and instructor 1. The interrater comparison yielded a Cronbach alpha of 0.710, which was an acceptable alpha. During course 2, 15 participants’ performance results were compared between the instructor and instructor 2. The interrater comparison yielded a Cronbach’s alpha of 0.734, which again reflected an acceptable alpha rating. In consideration of CPR’s variable instructor history these rating were considered acceptable measurements to show that the Adult CPR performance check list was a reliable instrument for checking the performance of participants in this study.
**Statistical Analysis**

All statistical analysis was done using IBM SPSS statistical software version 20.0. Analysis during this study focused on collecting data based on performance, attitude, and knowledge. Analytical efforts in this study were used to answer the following research questions: 1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? 2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? 3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? 4) What effect does time have on the retention of CPR participants between the control and treatment groups? Each one of the participants’ measurements evaluating performance and knowledge retention was obtained using standard test material or parameters for both control and treatment group, and surveys were used to gauge participants experience and attitudes. These same measurements were also conducted in the pilot study of this research to improve the future research approach during the main study, which was conducted the following semester, and all analysis during this study was conducted at a significance level of 0.05.

Both the pilot and main study of this research assessed the same criteria, although they had different timelines and statistical approaches to documenting the needed data. The pilot study occupied two time periods including the initial testing and one retesting in which repeated and independent measures t-test were used for within group comparisons as well as group to group comparisons over time. Its retesting period occurred four weeks after the initial CPR testing of the participants. This allowed for a comparison of means between or within groups with one independent and dependent variable. During
the main study there were three time periods that included initial testing, a first retesting, and a final retesting in which an ANOVA statistical analysis was used to determine within and between group differences. The testing and retesting timeline for this ANOVA design was composed of an initial CPR testing, a one week later retesting, and a final resting four weeks after the first retesting period. This analysis was used to determine if there was any difference or interaction in measurements related to the IVs time and group for all measurement criteria during the three time periods. Additionally independent t-tests were used at each time period to make direct comparisons between groups at specific times, and the identification of outliers that were three standard deviations or further away from the group means. Common statistics used during both pilot and main study periods involved the use of descriptives; that were used to better interrupt relationships between previous literature and occurring trends within this research for performance, knowledge, and attitude.

Performance assessments were conducted using a refined adult CPR checklist based on the traditional performance evaluation checklist approved by AHA. The Checklist evaluation was based on single person adult CPR which consisted of performance checks relative to the 2010 resuscitation guidelines. Performance checks were then measured in both pilot and main portions of this study. The performance checklist used during this study reflected on all six items used by the AHA standard performance checklist. These six items were expanded into an Adult performance check list that was composed of 11 sections with 33 individual procedural checks that reflected the six categorical checks used in the AHA approved standard performance checks. Additionally, each check list could now be measure with a maximum score of 50 points.
Point distribution was based on importance of the 2010 AHA CPR guidelines. Descriptive measurements were also used to indicate areas that participant’s measures during the performance evaluation. Data was gathered from both control and treatment groups to compare performance and determine if there was any difference between training periods.

Knowledge retention assessments were conducted using traditional testing material approved by the AHA. The exams used were AHA examinations for BLS healthcare providers. The initial testing included the collection of student data from the completion of the CPR course examination. Retestings followed the timeline design based on the pilot or main study using examination material to determine knowledge retention over time. Each participant’s results were averaged for each test then compared using t-test or ANOVA to determine if there was any significant increase or decrease in knowledge. T-test or ANOVA statistical methods were used to compare each initial and retesting periods for both groups to determine any differences in knowledge retained due to training types. These tests assisted in determining which training experience allowed participants to retain more knowledge over the course of the study period.

Attitude survey assessments were used to further understand the participants’ attitude. T-test or ANOVA analysis in conjunction with descriptive statistics were used to determine students’ attitudes of both control and treatment groups. To assist in identifying volunteers for recruitment purposes, experience was used as a partial measure once during each initial distribution of the survey, and based on “yes” or “no” type statements to indicate each participant’s experience level regarding CPR. Volunteers were excluded from the study if they answered “no” to experience question #3 and “yes”
to both experience question #4 and 5. Experience question #3 referred to “My last CPR course was before the new 2010 guidelines were introduced”, an indicated answer of “no” demonstrated that the volunteer had experience with 2010 AHA resuscitation guidelines. Experience question #4, “I have performed CPR in a hospital emergency” and experience question #5, “I have performed CPR in an out-of-hospital emergency” revealed that the volunteer had above average experience in both hospital and out-of-hospital cardiac arrest situations with 2010 AHA guidelines. Answering experience question #3, 4, and 5 in the previously mention manner would guarantee immediate volunteer exclusion from the study. Fortunately, none of the volunteers we excluded, and all were within the required experience range to participate in the study. The remainder of the attitude survey was set on a 5 point Likert scale with an answer range from “Strongly Disagree” to “Strongly Agree”. These measurements were used to display responses of each participant in both groups. Comparison between or within groups were used to determine if there was any significant change in attitude based on training conditions, self-efficacy, and environmental influences.
CHAPTER 4

RESULTS

Test results from this study were used to determine the effectiveness of integrating virtual training into CPR training as a means to promote preparedness among participants. This study contains both a pilot and main study. The pilot study was used to develop a foundation to support the main study, and as a result there were improvements made to the research analysis, testing materials, and procedure. These results represent the data collected during both pilot and main study to assist in gaining a further understanding in both the usage of virtual reality as an educational tool and the technological advancement of CPR training. It assisted in identifying common issues effecting CPR performance, knowledge and attitude due to variability among participants’ results reflected in literature, as well as answering necessary research question. In consideration of CPR’s variable history, outliers were also identified during the main study of this research. These were numerical values or data points that have an unusually high deviation from either the statistical mean or the median value. The deletion or removal of outliers is a controversial issue among the research community; therefore before any outliers were removed the original data was presented and analyzed as a part of this study’s documentation. Additional representation and analysis of results was provided to demonstrate the results of the data with and without outliers that are at least three standard deviations (SD) or more from the groups mean
**IRB Approval**

Prior to conducting any research on these participants Institutional Review Board (IRB) approval was obtained under protocol number X130207004. All testing material as well as data collections methods were reviewed and approved on February 11, 2013. Two additional amendments were added to this research study to allow for special population, change in consent forms, video recording of performance, compensation, and the adjustment in retesting time intervals from the pilot study to the main study. Final IRB approval was gained prior to conducting the main research study.

**Participant Compensation**

After obtaining IRB approval participants were compensated for both the pilot and main study of this research. The pilot study’s compensation required only two testing periods spaced 4 weeks apart. Participants were compensated $25.00 USD for completing the study and research materials. The main study’s compensation required three testing periods which included initial testing, one week later testing, and five weeks later testing after initial testing. Participants were compensated $40.00 USD for completing the study and research materials.

**Pilot Study Results**

The pilot study results were obtained using a control and treatment group during the summer semester, and both groups satisfied experience requirements demonstrating no significant difference in experience. The control group was used to for testing purposes to compare the use of integrating virtual reality enhancement training into the CPR classroom initially. It provided a preliminary measure to determine a base measurement of initial testing of traditional training and virtually enhanced training with
respect to performance, knowledge, and attitude to determine the advantages and disadvantages of using virtually enhanced training. The treatment group experienced the intervention of using virtual reality as a visual aid to enhance their CPR experience. It also provided a preliminary measure to determine a level equivalency or base measurement of initial testing of traditional training and virtually enhanced training with respect to performance, knowledge, and attitude, as well as a comparison of later retesting to determine the advantages and disadvantages of using virtually enhanced training. Results from this pilot testing were used to better understand and improve the testing procedures used in the main study.

**Control Group**

The control group was used to for testing purposes to compare the use of integrating virtual reality enhancement training into the CPR classroom initially. This group experienced traditional CPR training without the use of any intervention.

**Group Participants.** The pilot study control group’s participants were composed of a total of 27 students that were entering their first year of study within the School of Nursing at the university. Students were tested in the traditional classroom setting using traditional teaching methods for CPR. All students also were within the required experience range to be selected for this study.

**Control Group Results.** The control group had to undergo two test periods, an initial testing and retesting with the duration of four weeks between testing periods. Unfortunately, there was a discrepancy in attendance for the group’s retesting period, therefore the amount of retested individuals were heavily reduced. Initial testing included all 27 participants. Due to severe weather conditions the number of participants
that were retested was only six. The decrease in retaining participants prompted the consideration of only using the initial testing to determine whether virtual enhancement training could produce similar or equivalent results as a traditional CPR course cohort. Also outliers where identified and dealt with appropriately if they were present. Due to this preliminary study being only a pilot, outlier deletion was a less significant priority.

During the group’s initial testing period participants were evaluated based on three different criteria. Evaluations included measurements of course attitude, performance, and knowledge relevant to CPR. Participants’ results were later compared to the treatment group.

Attitude measurements were obtained using the final CPR survey, and were categorized into three different sections that measured the participant’s confidence, competence, and course attitude measured by frequency and descriptive analysis. Participants in the control group confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. The frequency distribution indicated that approximately 59.3 percent of participants rated their confidence levels at agreeable or greater, and 40.7 percent rated below agree but greater or equal to neutral. The 27 participants had a mean confidence score of $M = 4.1799$ (SD = 0.5265). Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. The frequency distribution indicated that approximately 70.4 percent of participants rated their competence levels at agreeable or greater, and 29.6 percent rated below agree but greater or equal to neutral. The 27 participants had a mean competence score of $M = 4.2741$ (SD = 0.4434). Course attitude measures also shared an identical range similar to both confidence and competence.
Although, there was similarity in range the percentage distribution showed an opposite relationship in regards to agreement. Approximately 37 percent of participants rated their course attitude levels at agreeable or greater, and 63 percent rated below agree but greater or equal to neutral. The 27 participants had a mean course attitude score of $M = 3.8519$ (SD = 0.43). In all three sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 24 to 48 out of a maximum score of 50. The frequency distribution indicated that about 85 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a $M = 43.0741$ (SD = 5.1286) among the 27 participants. The performance descriptive statistical analysis result indicates that a relatively high percentage of participants scored 80% or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given CPR test exam version A to obtain knowledge base measurements. Test scores ranged from 88 to 100, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 93.3333$ (SD = 4.9614). The descriptive statistical analysis of the test results indicated that all participants successfully passed the knowledge portion of the course.
Treatment Group

The treatment group experienced an intervention that involved the use of a virtual environment for the purpose of providing visual stimulation, and no other distractions or stimulants were used.

Group Participants. The pilot study treatment group’s participants were composed of a total of 13 students that were entering their first year of study within the Scholl of Nursing at the university. Students were tested using traditional classroom based CPR training with the addition of performing adult CPR while surround by a virtual environment. All students were within the required experience range to be selected for this study.

Treatment Group Results. This group also experienced two test periods, an initial testing and retesting with the duration of four weeks between testing periods. In this case there were no huge discrepancies in retesting attendance; therefore the group was able to successfully demonstrate the retention of skills and knowledge possibly due to using the virtual enhancement. Initially the group began with 13 students. 5 participants were eliminated during the retesting period of the study due to their absence, resulting in 8 of 13 students being retested. These participants provided a source to compare initial testing in relation to traditional CPR training, and also provided information on how virtually enhance training effects retention. Descriptive statistical analysis was also used in the evaluation of these participants.

During the group’s initial and retesting period participants were evaluated based on four different criteria. Evaluations included measurements of course attitude, performance, knowledge relevant to CPR, and their attitude towards virtual training.
Participants’ results were later compared to the control group’s initial testing period, and examined further during retesting to evaluate how much each participant retained after duration of 4 weeks.

**Initial Testing Period.** During the initial testing period, attitude measurements were obtained using the final CPR survey, and were categorized into four different sections that measured the participant’s confidence, competence, course attitude, and attitude towards virtual training. This group’s initial confidence measures ranged from disagree to strongly agree encompassing values from 2 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 69.2 percent or participants rated their confidence levels at agreeable or greater, and 30.8 percent rated below agree but greater than disagree. The 13 participants had a mean confidence score of $M = 4.033$ (SD $= 0.6339$). Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 69.2 percent of participants rated their competence levels at agreeable or greater, and 30.8 percent rated below agree but greater than neutral. The 13 participants had a mean competence score of $M = 4.239$ (SD $= 0.4154$). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 30.8 percent of participants rated their course attitude agreeable or greater, and 69.2 percent rated below agree but greater than neutral. The 13 participants had a mean course attitude score of $M = 3.8531$ (SD $= 0.3628$). Attitude towards virtual training measures ranged from neutral to strongly agree encompassing values of 3 to 5 on a 5 point Likert Scale. Frequency distributions indicated that approximately 46.2 percent of the participants rated their
attitude towards virtual training agreeable or greater, and 53.8 percent rated above neutral but below agree. The 13 participants had a mean virtual training attitude score of $M = 3.9451$ (SD = 0.4967). In all four sections participants’ total attitude reflected neutral or above relationships towards CPR and virtual training form the attitude survey given at the end of their CPR course based on the descriptive statistical analysis. Results also indicated that the virtual training was well received with an approximate agreeable rating.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from 22 to 48 out of a maximum score of 50. About 61.5 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a $M = 40.1538$ (SD = 6.9264) among the 13 participants. The performance descriptive statistical analysis demonstrates that a relatively high percentage of participants scored 80 percent or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass the course. Participants were given CPR test exam version A to obtain knowledge base measurements. Test scores ranged from 84 to 96, and only the first test grades without correction were collected for data analysis. This group’s test score mean, $M = 92.6154$ (SD = 3.5949). The frequencies of the test result indicated that 92.3 percent of participants passed the knowledge portion of the course, and 7.7 percent of participants required corrections to be made. The remaining 7.7 percent of participants rescored with a score of 88. The
descriptive statistical analysis of the test results indicated that all students successfully passed the knowledge portion of the course.

Retesting Period. The retesting period included evaluations of attitude, and performance measurements that followed the same design as in the initial testing. In reference to attitude, this group’s retested confidence measures ranged from disagree to strongly agree encompassing values from 2 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 62.5 percent or participants rated their confidence levels at agreeable or greater, and 37.5 percent rated below agree but greater than disagree. The eight participants had a mean confidence score of $M = 4.0714$ ($SD = 0.6434$). Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 87.5 percent of participants rated their competence levels at agreeable or greater, and 12.5 percent rated below agree but greater than neutral. The eight participants had a mean competence score of $M = 4.2375$ ($SD = 0.2615$). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 37.5 percent of participants rated their course attitude agreeable or greater, and 62.5 percent rated below agree but greater than neutral. The eight participants had a mean course attitude score of $M = 3.8295$ ($SD = 0.3451$). Attitude towards virtual training measures ranged from neutral to strongly agree encompassing values of 3 to 5 on a 5 point Likert Scale. Approximately 87.5 percent of the participants rated their attitude towards virtual training agreeable or greater, and 12.5 percent rated above neutral but below agree. The eight participants had a mean attitude towards virtual training score of $M = 3.9464$ ($SD = 0.3451$).
In all four sections participants’ total attitude reflected neutral or above relationships towards CPR and virtual training form the attitude survey given at the end of their CPR course based on the descriptive statistical analysis. Results also indicated that the virtual training was remained in favor with an approximate agreeable rating.

The remaining eight participants’ performance measures were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from 43 to 50 out of a maximum score of 50. 100 percent of the participants’ performance measured 40 out of 50 or greater with 7 of the 8 participants scoring 47 out of 50 or above. Total performance showed that this group had a \( M = 47.75 \) (SD = 2.2520) among the eight participants. The performance descriptive statistical analysis demonstrates that a relatively high percentage of participants scored 94 percent or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass the course. Participants were given CPR test exam version B to obtain knowledge base measurements. Version B of the CPR test reflected the necessary CPR knowledge requirements. Version B of the CPR exam was also considered an alternative and equivalent test approved by the AHA. The 8 participants’ test scores ranged from 52 to 92, and only the first test grades without correction were collected for data analysis. This group’s test score mean, \( M = 76.5000 \) (SD = 14.5700). The frequency distributions of the test result indicated that 37.5 percent of participants passed the knowledge portion of the course, and 62.5 percent of participants failed. The descriptive statistical analysis of the test results indicated that the
majority of participants failed the knowledge portion of the course during the 4 week later retesting period.

**Treatment Group Test Retest Comparison.**

Initial testing condition for the treatment group incorporated virtual enhancement CPR training with no distractions and only the visualization of the virtual environment. After a 4 week duration, returning participants from the same group were retested within a traditional classroom setting. Retesting sessions did not include any review, and participants were immediately asked to perform CPR after entering the room. Also to limit the influence of the participants recalling CPR procedure information by witnessing another participant perform CPR, only one participant was allowed to be retested at a time. Remaining participants were asked to wait outside of the room until called. The waiting area for the participants was also moved away from the entrance of the room to reduce the chance of overhearing the CPR procedure. Participants were also asked to provide times in which they would come to be retested to limit the interaction between participants in the waiting area. Although participants’ performance was individually performed due to this study being performed on a life-saving process the CPR instructor was always allowed to provide corrective feedback for each participant after each testing session.

Test retest comparisons were made using repeated measures t-test. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each student at test time one (initial testing) and test time two (retesting). Also due to participants not returning for retesting their scores were not considered during the test retest comparison. Those deletions caused minor shifts in
initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data.

For test retest measurements of attitude, this group’s initial testing and retesting measures were collected and compared for confidence, competence, course attitude, and attitude towards virtual training. All measures remained on the previously used scale for initial and retesting periods. Repeated measures t-tests were conducted on participants’ attitude to compare each DV including confidence, competence, course attitude, and attitude towards virtual training at the IVs initial testing with virtual enhancement training and retesting with traditional classroom training time periods. Confidence comparisons between the two testing time periods indicated that there was not a significant difference in scores for the initial testing (M = 3.9643, SD = 0.6558) and retesting (M = 4.0714, SD = 0.6434) conditions; t(7) = -0.6, p = 0.567. Competence comparisons between the two testing time periods indicated that there was not a significant difference in scores for the initial testing (M = 4.2000, SD = 0.4276) and retesting (M = 4.2375, SD = 0.2615); t(7) = -0.369, p = 0.723. Course attitude comparisons between the two testing time periods indicated that there was not a significant difference in scores for the initial testing (M = 3.9091, SD = 0.2706) and retesting (M = 3.8295, SD = 0.345); t(7) = 0.853, p = 0.422. Attitude towards virtual training comparisons between the two testing time periods indicated that there was not a significant difference in scores for the initial testing (M = 3.9464, SD = 0.3963) and retesting (M = 3.9464, SD = 0.2151); t(7) = 0.000, p = 1.000. These repeated measures t-test results show that there was no significant difference in attitude over the course of the pilot study for the treatment group.
Repeated measures t-test were also conducted on participants’ performance and knowledge with each DV including performance scores, and test scores respectively; the IVs initial testing with virtual enhancement training and retesting with traditional classroom training time periods for performance and knowledge. Performance comparisons between the two testing time periods indicated that there was not a significant difference in scores for the initial testing (M = 41.1250, SD = 2.9727) and retesting (M = 47.75, SD = 0.7962); t(7) = -1.936, p = 0.094. Knowledge comparisons between the two testing time periods indicated that there was a significant difference in scores for the initial testing (M = 92.50, SD = 0.9063) and retesting (M = 76.5, SD = 5.1513); t(7) = 2.880, p = 0.024. These results show that there was not any change in performance over time, but there was a significant difference in test scores over time.

**Initial Testing Control and Treatment Group Comparison**

During this pilot study independent t-test were conducted between the initial testing periods of both the control and treatment groups. This statistical analysis was used to determine if there would be any difference between the comparison of virtual enhanced CPR training and traditional CPR training. Comparisons were made at the initial testing time period for attitude, performance, and knowledge between the control and treatment group. These comparisons also provided a base line measurement for group equivalency that indicated that there was no significant difference in both groups in all criteria.

An independent samples t-test was conducted on participants’ attitude to compare each DV including confidence, competence, and course attitude at the initial testing control group with traditional CPR training and treatment group with virtual
enhancement training. Independent samples t-test confidence comparisons between the two groups indicated that there was not a significant difference in scores for the control group (M = 4.1799, SD = 0.5265) and treatment group (M = 4.033, SD = 0.6339) conditions; t(38) = 0.774, p = 0.444. Competence comparisons between the two groups indicated that there was not a significant difference in scores for the control group (M = 4.2741, SD = 0.4434) and treatment group (M = 4.2385, SD = 0.4154) conditions; t(38) = 0.243, p = 0.810. Course attitude comparisons between the two groups indicated that there was not a significant difference in scores for the control group (M = 3.8519, SD = 0.43) and treatment group (M = 3.8531, SD = 0.3628) conditions; t(38) = -0.009, p = 0.993. Results shown during this independent t-test indicated that there was no significant difference in initial attitude between both control and treatment groups.

Independent t-test were also conducted on participants’ performance and knowledge with each DV including performance scores, and test scores respectively; the IVs control group with traditional CPR training and treatment group with virtual enhancement training for performance and knowledge. Performance comparisons between the two groups indicated that there was not a significant difference in scores for the control group (M = 43.0741, SD = 5.1286) and treatment group (M = 40.1538, SD = 6.9264) conditions; t(38) = 1.503, p = 0.141. Knowledge comparisons between the two groups indicated that there was not a significant difference in scores for the control group (M = 92.5926, SD = 5.9437) and treatment group (M = 92.6154, SD = 3.5949) conditions; t(35.774) = -0.015, p = 0.988. Knowledge comparison did have a Levene’s Test for Equality of Variance as significant at 0.01 indicating that there was some variability among means in the groups. These results showed that there was no
difference in both the control and treatment group in performance and knowledge at the initial testing period.

**Main Study Results**

The primary results of this study were obtained during the following Fall semester. Testing included the evaluation of CPR participants recruited from a School of Nursing curriculum. Eligible participants were then placed within the control or treatment group and then asked to undergo CPR training. All participants in both groups satisfied experience requirements for this research study. Participants results were collected using the criteria of performance, knowledge, and attitude to assist in answering the following research questions: 1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? 2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? 3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? 4) What effect does time have on the retention of CPR participants between the control and treatment groups? These questions were used to identify possible methods that could increase CPR retention, and the understanding of the uses of virtual reality as an educational tool. An ANOVA type design was used during this study that allowed participants to experience traditional classroom CPR training as a baseline measure for initial training among both group. This design also included two retesting periods. Retesting period one occurred one week after the initial baseline measurement, and allowed for the introduction of intervention to be introduced to the treatment group. Retesting period two occurred four weeks after the retesting period one, and provided a measure of effectiveness of the two training approaches used
during this study. Additional information in this study was provided by the use of independent t-test, descriptive statistics, and the identification and reanalysis of outliers.

**Control Group**

The control group was used for testing purposes to compare the use of integrating virtual reality enhancement training into the CPR training. This group experienced traditional CPR training without the use of any intervention.

**Group Participants.** Control group participants were composed of a total of 19 volunteer pre-nursing students that followed a designated School of Nursing curriculum at the university. Students were tested in the traditional classroom setting using traditional teaching methods for CPR. All students also were within the required experience range to be selected for this study.

**Control Group Results.** During this study the control group had to undergo three test periods, an initial testing, retesting period one, and retesting period two. There were little to no discrepancies in attendance for this group’s testing periods, and majority of the participants returned for the final retesting. Initial testing included 19 participants, and 17 participants completed the final retesting period. Therefore the results of only 17 participants were considered for the control group’s statistical analysis. Also outliers where identified and dealt with appropriately if they were present during the study. Original data and analysis was always reported and represented, as well as data without outlier influence. Both data sets were analyzed in the areas of CPR training attitude, performance, and knowledge.

**Initial Testing.** During the group’s initial testing period participants were evaluated based on three different criteria. Evaluations included measurements of course
attitude, performance, and knowledge relevant to CPR. Participants’ results were later compared to the treatment group.

Attitude measurements were obtained using the final CPR survey, and were categorized into three different sections that measured the participant’s confidence, competence, and course attitude. Confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 52.9 percent of participants rated their confidence levels at agreeable or greater, and 47.1 percent rated below agree but greater or equal to neutral. The 17 participants had a mean confidence score of \( M = 3.9328 \) (SD = 0.4926).

Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 76.5 percent of participants rated their competence levels at agreeable or greater, and 23.5 percent rated below agree but greater or equal to neutral. The 17 participants had a mean competence score of \( M = 4.2059 \) (SD = 0.4337). Course attitude measures also shared an identical range similar to both confidence and competence. Although, there was similarity in range the percentage distribution showed an opposite relationship in regards to agreement. Frequency distributions indicated that approximately 41.2 percent of participants rated their course attitude levels at agreeable or greater, and 58.8 percent rated below agree but greater or equal to neutral. The 17 participants had a mean course attitude score of \( M = 3.8449 \) (SD = 0.3274). In all three sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.
Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 42 to 48 out of a maximum score of 50. About 100 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a mean performance score of $M = 46.1176$ (SD = 2.20461) among the 17 participants. The performance descriptive statistical analysis result indicates that all participants scored 80 percent or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given CPR test exam version A to obtain knowledge base measurements. Test scores ranged from 72 to 100, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 93.1765$ (SD = 7.7155). The descriptive statistical analysis of the test results indicated that 14 participants successfully passed the knowledge portion of the course with the exception of three participants failing the first attempt. These students were retested to obtain passing scores.

**Retesting Period One.** Retesting period one included evaluations of attitude, and performance measurements that followed the same design as in the initial testing. In reference to attitude, this group’s retested confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 35.3 percent or participants rated their confidence levels at agreeable or greater, and 64.7 percent rated below agree but greater than neutral. The 17 participants had a mean confidence score of $M = 3.8655$ (SD =
Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 58.8 percent of participants rated their competence levels at agreeable or greater, and 41.2 percent rated below agree but greater than neutral. The 17 participants had a mean competence score of \( M = 4.1765 \) (SD = 0.4603). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 29.4 percent of participants rated their course attitude agreeable or greater, and 70.6 percent rated below agree but greater than neutral. The 17 participants had a mean course attitude score of \( M = 3.8396 \) (SD = 0.3348). In all three sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 31 to 50 out of a maximum score of 50. About 94.1 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a performance mean of \( M = 45.4706 \) (SD = 4.4176) among the 17 participants. The performance descriptive statistical analysis result indicated that 16 of 17 participants scored 80 percent or better demonstrating that they were able to perform CPR. It is also important to consider that due to this being a study pertaining to a life-saving process that the instructor was able to provide corrective feedback for performance after retesting was completed which could have an effect on CPR performance.
Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88. Participants were given a CPR modified test exam version B including five additional questions, but only questions that reflected version A were graded to obtain knowledge base measurements. Test scores ranged from 64 to 100, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 88.4706$ (SD = 9.2609). The descriptive statistical analysis of the test results indicated that 11 participants successfully passed the knowledge portion of the course with the exception of six participants failing. There were no reattempts giving during retesting periods.

**Retesting Period Two.** Retesting period two included evaluations of attitude and performance measurements that followed the same design as in the initial testing. In reference to attitude, this group’s retested confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 58.8 percent or participants rated their confidence levels at agreeable or greater, and 41.2 percent rated below agree but greater than neutral. The 17 participants had a mean confidence score of $M = 3.9832$ (SD = 0.5478). Competence measures ranged from disagree to strongly agree encompassing values from 1 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 70.6 percent of participants rated their competence levels at agreeable or greater, and 29.4 percent rated below agree but greater than strongly disagree. The 17 participants had a mean competence score of $M = 3.9824$ (SD = 0.7282). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 23.5 percent of
participants rated their course attitude agreeable or greater, and 76.5 percent rated below agree but greater than neutral. The 17 participants had a mean course attitude score of $M = 3.7754$ (SD = 0.3017). In all three sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 44 to 50 out of a maximum score of 50. About 100 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a mean score of $M = 48.1176$ (SD = 2.058) among the 17 participants. The performance descriptive statistical analysis result indicates that all participants scored 80 percent or better demonstrating that they were able to perform CPR. It is also important to consider that due to this being a study pertaining to a life-saving process that the instructor provided corrective feedback for performance after testing was completed which could have an effect on CPR performance.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given a CPR modified test exam version C including five additional questions, but only questions that reflected version A were graded to obtain knowledge base measurements. Test scores ranged from 64 to 96, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 86.8235$ (SD = 8.9179). The descriptive statistical analysis of the test results indicated that 10 participants successfully
passed the knowledge portion of the course with the exception of seven participants failing. There were no reattempts giving during retesting periods.

**Control Group Test Retest Comparison**

Testing conditions for the control group incorporated traditional CPR training with no interventions. Retesting period one occurred after one week time duration after initial testing, and retesting period two occurred four weeks after retesting one. All returning participants from the same group were retested within a traditional classroom setting. Retesting sessions did not include any review, and participants were immediately asked to perform CPR after entering the room. Also to limit the influence of the participants recalling CPR procedure information by witnessing another participant perform CPR, only one participant was allowed to be retested at a time. Remaining participants were asked to wait outside of the room until called. The waiting area for the participants was also moved away from the entrance of the room to reduce the chance of overhearing the CPR procedure. Participants were also asked to provide times in which they would come to be retested to limit the interaction between participants in the waiting area. Although participants’ performance was individually performed due to this study being performed on a life-saving process the CPR instructor was always allowed to provide corrective feedback for each participant after each testing session.

Test retest comparisons were made using repeated measures ANOVA with polynomial contrast. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each student at test time one (initial testing), test time two (retesting period one), and test time three (retesting period two), and polynomial contrast allowed for the identification of the line
or data trend as linear, quadratic, or cubic. Polynomial contrasts and post hoc test were only mentioned if the line trend or test was significant for participants’ data. Also due to participants not returning for retesting their scores were not considered during the test retest comparison. Those deletions caused minor shifts in initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data.

For test retest measurements of attitude, this group’s initial testing and retesting measures were collected and compared for confidence, competence, and course attitude. All measures remained on the previously used scale for initial and retesting periods. Repeated measures ANOVA was conducted on participants’ attitude to compare the effects of the IV time on each DV including confidence, competence, and course attitude in initial testing, retesting period one, and retesting period two conditions. Confidence comparisons between the three testing time periods indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.902, F(2, 15) = 0.817, p = 0.461, eta^2 = 0.098, observed power = 0.164. Confidence repeated measures comparison using time as the within subjects factor did not violate the Mauchy’s Test of Sphericity at a significance level of 0.770. Figure 4.1 shows confidence mean measurements over time for the control group for each time period.
Competence comparisons between the three testing time periods also indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.910, F(2, 15) = 0.745, p = 0.492, \( \eta^2 = 0.090 \), observed power = 0.153. Competence repeated measures comparison using time as the within subjects factor was violated with Mauchy’s Test of Sphericity test at a significance level of 0.004. Due to the violation of the sphericity assumption, the Greenhouse-Geisser correction was used with F(1.309, 20.939) = 1.278, p = 0.284, \( \eta^2 = 0.074 \), observed power = 0.209. Figure 4.2 shows competence mean measurements over time for the control group for each time period.
Course attitude comparisons between the three testing time periods also indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.915, $F(2, 15) = 0.696, p = 0.514$, $\eta^2 = 0.085$, observed power = 0.146. Course attitude repeated measures comparison using time as the within subjects factor did not violate the Mauchy’s Test of Sphericity at a significance level of 0.249. Figure 4.3 shows course attitude mean measurements over time for the control group for each time period.
Results indicated that there was a starting decline in control group participants’ competence, and course attitude with the exception of confidence; although there was no significant difference found in participants’ confidence, competence, and course attitude over time.

For test retest measurements of performance, this group’s initial testing and retesting measures were collected and compared during the adult CPR procedure. All measures remained on the previously used scale for initial and retesting periods. Repeated measures ANOVA was conducted on participants’ performance to compare the effects of IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. Prior performance comparisons readings between the three testing time periods also indicated that there was a significant effect in scores for time, Wilk’s Lambda = 0.484, F(2, 15) = 7.988, p = 0.004, eta² = 0.516, observed
power = 0.907. Performance repeated measures comparison using time as the within subjects factor was violated with Mauchy’s Test of Sphericity test at a significance level of 0.004. However, due to the violation of the sphericity assumption, the Greenhouse-Geisser correction was used with F(1.397, 22.344) = 3.485, p = 0.063, \( \eta^2 = 0.179 \), observed power = 0.502 and showed no significant effect for time. Figure 4.4 shows performance mean measurements over time for the control group for each time period.

![Estimated Marginal Means of Control Group Performance](image)

**Figure 4.4** Control Group Performance Means - Shows the control group’s performance means overtime

Although further analysis using polynomial contrasts indicate a significant linear trend over time, \( F(1,16) = 8.119, p = 0.12, \eta^2 = 0.337 \), observed power = 0.763. The post hoc test also showed a significant difference between time 1 (initial testing period) and time 3 (retesting period two), \( p = 0.012 \), and between time 2 (retesting period one) and time 3 (retesting period two), \( p = 0.20 \) at a 95% confidence interval. These results were no longer valid as well as their significant change in performance primarily between the
initial testing period and retesting period one when compared to retesting period two. The figure 4.4 indicates a slight decline in participants’ performance from the initial testing to retesting period one, and an increase in participants’ performance after retesting period one to retesting two for the control group.

Test retest measurements of knowledge were collected and compared during the adult CPR procedure from the initial testing and retesting measures. All measures remained on the previously used scale for initial and retesting periods. Repeated measures ANOVA was conducted on participants’ knowledge to compare the effects of IV time on the DV test score in initial testing, retesting period one, and retesting period two conditions. Knowledge comparisons between the three testing time periods indicated that there was a significant effect in scores for time, Wilk’s Lambda = 0.383, F( 2, 15) = 12.105, p = 0.001, eta² = 0.617, observed power = 0.983. Knowledge repeated measures comparison using time as the within subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.189. Test score mean measurements decreased over time for the control group for each time period. Figure 4.5 shows test score mean measurements over time for the control group for each time period.
Further analysis using polynomial contrasts indicate a significant linear trend over time, F(1,16) = 15.552, p = 0.001, \( \eta^2 \) = 0.493, observed power = 0.959. Additionally, the post hoc test also showed a significant difference between time 1 (initial testing period) and time 2 (retesting period one), p = 0.002, and between time 1 (initial testing period) and time 3(retesting period two), p = 0.001 at a 95% confidence interval. These results indicated that there was a significant change in test scores primary between the initial testing period when compared to retesting period one and retesting period two. The figure 4.5 indicates a significant decline in participants’ knowledge from the initial testing to retesting period one, and a slight decrease in participants’ knowledge after retesting period one to retesting two for the control group.

**Figure 4.5** Control Group Knowledge Means - Shows the control group’s test score means overtime
Treatment Group

The treatment group experienced an intervention that involved the use of a virtual environment for the purpose of providing visual stimulation. Additionally visual and auditory distractions were used to provide a mixed reality training scenario.

**Group Participants.** Treatment group’s participants were composed of a total of 21 volunteer pre-nursing students that followed a designated School of Nursing curriculum at the university. Students were tested using traditional classroom based CPR training with the addition of performing adult CPR while surrounded by a virtual environment in a mixed reality CPR training simulation. All students were within the required experience range to be selected for this study.

**Treatment Group Results.** During this study the treatment group had to undergo three test periods, an initial testing, retesting period one, and retesting period two. There were little to no discrepancies in attendance for this group’s testing periods, and all participants returned for the final retesting. Initial testing included 21 participants, and all participants completed the final retesting period. Therefore the results of all 21 participants were considered for the treatment group’s statistical analysis. Also outliers where identified and dealt with appropriately if they were present during the study. Original data and analysis was reported and represented, as well as data without outlier influence. Both data sets were analyzed in the areas of CPR training attitude, performance, and knowledge.

**Initial Testing.** During the group’s initial testing period participants were evaluated based on three different criteria. Evaluations included measurements of course
attitude, performance, and knowledge relevant to CPR. Participants’ results were later compared to the control group and served as a baseline measure for both groups.

Attitude measurements were obtained using the final CPR survey, and were categorized into three different sections that measured the participant’s confidence, competence, and course attitude. Confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 66.7 percent of participants rated their confidence levels at agreeable or greater, and 33.3 percent rated below agree but greater or equal to neutral. The 21 participants had a mean confidence score of $M = 4.2041$ (SD = 0.5413).

Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 61.9 percent of participants rated their competence levels at agreeable or greater, and 38.1 percent rated below agree but greater or equal to neutral. The 21 participants had a mean competence score of $M = 4.1714$ (SD = 0.4971). Course attitude measures also shared an identical range similar to both confidence and competence. Although, there was similarity in range the percentage distribution showed an opposite relationship in regards to agreement. Approximately 38.1 percent of participants rated their course attitude levels at agreeable or greater, and 61.9 percent rated below agree but greater or equal to neutral. The 21 participants had a mean course attitude score of $M = 3.9091$ (SD = 0.3056). In all three sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.
Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 40 to 48 out of a maximum score of 50. About 100 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a mean performance score of $M = 45.7143$ (SD = 2.5718) among the 21 participants. The performance descriptive statistical analysis result indicated that all participants scored 80 percent or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given CPR test exam version A to obtain knowledge base measurements. Test scores ranged from 80 to 96, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 90.6667$ (SD = 4.2583). The descriptive statistical analysis of the test results indicated that 19 participants successfully passed the knowledge portion of the course with the exception of two participants failing the first attempt. These students were retested to obtain passing scores.

**Retesting Period One.** Retesting period one included evaluations of attitude, and performance measurements that followed the same design as in the initial testing with the addition of the evaluation of attitude towards virtual training. A performance intervention was introduced that allowed students to perform CPR within a mixed reality CPR simulation. The simulation included a visual representation of an apartment kitchen, light smoke and a radio were introduced to provide visual and auditory distractions. Visually the smoke was light enough to allow participants to perform CPR
and not deter them from the task at hand, but it did provide a warning of possible danger pertaining to scene safety. The radio provided a noticeable auditory distraction that would be expected in that environment.

In reference to attitude, this group’s retested confidence measures ranged from disagree to strongly agree encompassing values from 2 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 51.1 percent or participants rated their confidence levels at agree or greater, and 42.9 percent rated below agree but greater than disagree. The 21 participants had a mean confidence score of $M = 4.0805$ (SD = 0.5527). Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 52.4 percent of participants rated their competence levels at agreeable or greater, and 47.6 percent rated below agree but greater than neutral. The 21 participants had a mean competence score of $M = 4.2238$ (SD = 0.4647). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 38.1 percent of participants rated their course attitude agreeable or greater, and 61.9 percent rated below agree but greater than neutral. The 21 participants had a mean course attitude score of $M = 3.9524$ (SD = 0.4092). Attitude towards virtual training measures ranged from disagree to strongly agree encompassing values of 2 to 5 on a 5 point Likert Scale. Frequency distributions indicated that approximately 52.4 percent of participants rated their attitude towards virtual training levels at agreeable or greater, and 47.6 percent rated below agree but greater than disagree. The 21 participants had a mean virtual training attitude score of $M = 3.9184$ (SD = 0.5653). These values for attitude towards virtual training
indicated that the mixed reality simulation was well received by a majority of participants. In all four sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a mixed reality cardiac arrest scenario. This group’s performance ranged from a minimum score of 39 to 50 out of a maximum score of 50. About 90.5 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a mean performance score of $M = 46.7619$ (SD = 3.4627) among the 21 participants. The performance descriptive statistical analysis result indicates that 19 of 21 participants scored 80 percent or better demonstrating that they were able to perform CPR. It is also important to consider that due to this being a study pertaining to a life-saving process that the instructor provided corrective feedback for performance after retesting was completed which could have an effect on CPR performance.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given a CPR modified test exam version B including five additional questions, but only questions that reflected version A were graded to obtain knowledge base measurements. Test scores ranged from 62 to 96, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 86.3810$ (SD = 7.5265). The descriptive statistical analysis of the test results indicated that 13 participants successfully
passed the knowledge portion of the course with the exception of eight participants failing. There were no reattempts giving during retesting periods.

**Retesting Period Two.** Retesting period two included evaluations of attitude, and performance measurements that followed the same design as in the initial testing with no intervention. Participants’ performance was moved back into the traditional classroom setting with no interventions. In reference to attitude, this group’s retested confidence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 66.7 percent or participants rated their confidence levels at agree or greater, and 33.3 percent rated below agree but greater than neutral. The 21 participants had a mean confidence score of $M = 4.1701$ (SD = 0.6188). Competence measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 61.9 percent of participants rated their competence levels at agreeable or greater, and 38.1 percent rated below agree but greater than neutral. The 21 participants had a mean competence score of $M = 4.20$ (SD = 0.4472). Course attitude measures ranged from neutral to strongly agree encompassing values from 3 to 5 on a 5 point Likert scale. Frequency distributions indicated that approximately 57.1 percent of participants rated their course attitude agreeable or greater, and 42.9 percent rated below agree but greater than neutral. The 21 participants had a mean course attitude score of $M = 4.013$ (SD = 0.3417). Attitude towards virtual training measures ranged from disagree to strongly agree encompassing values of 2 to 5 on a 5 point Likert Scale. Frequency distributions indicated that approximately 66.7 percent of participants rated their attitude towards virtual training levels at agreeable or greater, and
33.3 percent rated below agree but greater than disagree. The 21 participants had a mean virtual training attitude score of $M = 4.0612$ (SD = 0.6398). These values for attitude towards virtual training indicate that feeling towards the mixed reality simulation began to improve as participants were brought back into a traditional setting. In all four sections participants’ total attitude reflected neutral or above relationships towards CPR from the attitude survey given at the end of their CPR course based on the descriptive statistical analysis.

Participant performance checklist measurements were used to determine their level of efficiency displayed during the reenactment of performing CPR procedure during a cardiac arrest scenario. This group’s performance ranged from a minimum score of 33 to 50 out of a maximum score of 50. Frequency distributions indicated that about 85.7 percent of participants’ performance measured 40 out of 50 or greater. Total performance showed that this group had a mean performance score of $M = 45.0476$ (SD = 4.6204) among the 21 participants. The performance descriptive statistical analysis result indicated that 16 of 21 participants scored 80 percent or better demonstrating that they were able to perform CPR.

Knowledge measurements measured by routine test included a 25 question exam, in which each participant required a score of 88 to pass. Participants were given a CPR modified test exam version C including five additional questions, but only questions that reflected version A were graded to obtain knowledge base measurements. Test scores ranged from 60 to 96, and only the first test grades without corrections were collected for data analysis. This group’s tests score mean, $M = 82.8571$ (SD = 8.1135). The descriptive statistical analysis of the test results indicated that six participants
successfully passed the knowledge portion of the course with the exception of 15 participants failing. There were no reattempts giving during retesting periods.

**Treatment Group Test Retest Comparison.**

Testing conditions for the treatment group incorporated traditional CPR training with the intervention of a mixed reality CPR simulation with visual and auditory distractions. Retesting period one occurred after one week time duration after initial testing, and retesting period two occurred four weeks after retesting one. All returning participants from the same group were retested within a traditional classroom setting. Retesting sessions did not include any review, and participants were immediately asked to perform CPR after entering the room. Also to limit the influence of the participants recalling CPR procedure information by witnessing another participant perform CPR, only one participant was allowed to be retested at a time. Remaining participants were asked to wait outside of the room until called. The waiting area for the participants was also moved away from the entrance of the room to reduce the chance of overhearing the CPR procedure. Participants were also asked to provide times in which they would come to be retested to limit the interaction between participants in the waiting area. Although participants’ performance was individually performed due to this study being performed on a life-saving process the CPR instructor provided corrective feedback for each participant after each testing session.

Test retest comparisons were made using repeated measures ANOVA with polynomial contrast. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each student at test time one (initial testing), test time two (retesting period one), and test time three.
(retesting period two), and polynomial contrast allowed for the identification of the line
or data trend as linear, quadratic, or cubic. Polynomial contrasts and post hoc test were
only performed if the line trend or test was significant for participants’ data.

For test retest measurements of attitude, this group’s initial testing and retesting
measures were collected and compared for confidence, competence, and course attitude.
All measures remained on the previously used scale for initial and retesting periods.
Repeated measures ANOVA was conducted on participants’ attitude to compare the
effects of the IV time on each DV including confidence, competence, and course attitude
in initial testing, retesting period one, and retesting period two conditions. Confidence
comparisons between the three testing time periods indicated that there was not a
significant effect in scores for time, Wilk’s Lambda = 0.929, F( 2, 19) = 0.722, p = 0.499,
eta² = 0.071, observed power = 0.154. Confidence repeated measures comparison using
time as the within subjects factor did not violate the Mauchy’s Test of Sphericity at a
significance level of 0.820. Figure 4.6 shows confidence mean measurements over time
for the treatment group for each time period.
Competence comparisons between the three testing time periods also indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.948, $F(2, 19) = 0.516$, $p = 0.605$, eta$^2 = 0.052$, observed power = 0.123. Competence repeated measures comparison using time as the within subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.152. Figure 4.7 shows competence mean measurements over time for the treatment group for each time period.
Course attitude comparisons between the three testing time periods also indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.834, F(2, 19) = 1.886, p = 0.179, \( \eta^2 = 0.166 \), observed power = 0.343. Course attitude repeated measures comparison using time as the within subjects factor was not violated with Mauchy’s Test of Sphericity at a significance level of 0.774. Figure 4.8 shows course attitude mean measurements over time for the treatment group for each time period.
Test retest comparisons were also made using repeated measures t-test. This type of statistical analysis allowed for the measurement the intervention response of attitude towards virtual training based on reevaluating and comparing each student at test time two (retesting period one), and test time three (retesting period two). For test retest measurements of attitude towards virtual training, this group’s retesting measures were collected and compared. All measures remained on the previously used scale for initial and retesting periods. A repeated measured t-test was conducted on participants’ attitude to compare the effects of the IV time on the DV attitude towards virtual training in retesting period one and retesting period two conditions. Attitude towards virtual training comparisons between the two testing time periods indicated that there was not a significant difference in scores for the retesting period one (M = 3.9184, SD = 0.5653) and retesting period two (M = 4.0612, SD = 0.6398) conditions; t(20) = -1.175, p =
0.254. Figure 4.9 shows attitude towards virtual training mean measurements over time for the treatment group for time period one and two.

![Estimated Marginal Means of Attitude Towards Virtual Training Average](image)

**Figure 4.9** Treatment Group Virtual Training Attitude Means - Shows attitude towards virtual training mean measurements over time for the treatment group

Results indicated that there was a slight increase in the treatment group participants’ competence, and course attitude with the exception of confidence from the initial testing period to the intervention in retesting period one. From retesting period one to retesting period two confidence and course attitude experienced a slight increase, but competence experience a slight decrease in attitude. Although there were fluctuations among participants’ confidence, competence, and course attitude there was no significant difference found among the three over time. Additionally the use of the intervention for attitude from virtual training showed a slight increase between retesting period one and two. Although the increase was non-significant it did show a slight increase in attitude
towards virtual training after participants’ were returned to a traditional classroom setting for the final testing.

Test retest measurements of performance, this group’s initial testing and retesting measures were collected and compared during the adult CPR procedure. All measures remained on the previously used scale for initial and retesting periods. Repeated measures ANOVA was conducted on participants’ performance to compare the effects of IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. Performance comparisons between the three testing time periods also indicated that there was not a significant effect in scores for time, Wilk’s Lambda = 0.877, \( F(2, 19) = 1.336, p = 0.287, \eta^2 = 0.123 \), observed power = 0.253. Performance repeated measures comparison using time as the within subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.051. Figure 4.10 shows performance mean measurements over time for the treatment group for each time period.
These results indicate that there was not a significant change in performance primary throughout the initial testing period, retesting period one, and retesting period two. The figure indicates a slight increase in participants’ performance from the initial testing to retesting period one, and a slight decrease in participants’ performance after retesting period one to retesting two.

For test retest measurements of knowledge, this group’s initial testing and retesting measures were collected and compared during the adult CPR procedure. All measures remained on the previously used scale for initial and retesting periods. Repeated measures ANOVA was conducted on participants’ knowledge to compare the effects of the IV time on the DV test score in initial testing, retesting period one, and retesting period two conditions. Knowledge comparisons between the three testing time periods indicated that there was a significant effect in scores for time, Wilk’s Lambda =
0.572, F(2, 19) = 7.112, p = 0.005, \( \eta^2 = 0.428 \), observed power = 0.885. Knowledge repeated measures comparison using time as the within subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.976. Test score mean measurements decreased over time for the treatment group for each time period. Figure 4.11 shows test score mean measurements over time for the treatment group for each time period.

![Estimated Marginal Means of Treatment Group Test Scores](image)

**Figure 4.11** Treatment Group Knowledge Means - Shows the treatment group’s test score means overtime

Further analysis using polynomial contrasts indicate a significant linear trend over time, F(1,20) = 14.969, p = 0.001, \( \eta^2 = 0.428 \), observed power = 0.957. Additionally, post hoc test also showed a significant difference between time 1 (initial testing period) and time 3 (retesting period two), p = 0.001 at a 95% confidence interval. These results indicated that there was a significant change in test scores primarily between the initial testing period and retesting period two. The figure 4.11 indicates a decrease in
participants’ knowledge from the initial testing to retesting period one, and a slight
decrease in participants’ knowledge after retesting period one to retesting two. The
results are further supported by a significant linear trend from polynomial contrast, and
an identified significance between the initial testing period and retesting period two by
post hoc test for the treatment group.

**Independent Group Comparisons**

Group comparison testing conditions for both groups incorporated traditional
CPR training course to provide a baseline measure of equivalency among the groups.
Both groups were considered equivalent in showing no difference in comparisons of all
analyzed criteria of this study during their initial testing. Additionally both groups
showed no significant difference when comparing their experience during the initial
distribution of the survey tool for 17 control participants and 21 treatment group
participants. An independent samples t-test was used to compare participants’ experience
in the initial training period in the control and treatment group conditions. There was not
a significant difference in scores for the control group (M = 0.3241, SD = 0.0251) and
treatment group (M = 0.3917, SD = 0.025) conditions; t(36) = -1.903, p = 0.065.

Both groups had to undergo an initial testing, retesting period one occurred after
one week time duration after initial testing, and retesting period two occurred four weeks
after retesting one. All returning participants from the same group were retested within a
traditional classroom setting. Retesting sessions did not include any review, and
participants were immediately asked to perform CPR after entering the room. Also to
limit the influence of the participants recalling CPR procedure information by witnessing
another participant perform CPR, only one participant was allowed to be retested at a
time. Remaining participants were asked to wait outside of the room until called. The waiting area for the participants was also moved away from the entrance of the room to reduce the chance of overhearing the CPR procedure. Participants were also asked to provide times in which they would come to be retested to limit the interaction between participants in the waiting area. Although participants’ performance was individually performed due to this study being performed on a life-saving process the CPR instructor was allowed to provide corrective feedback for each participant after each testing session.

Independent group comparisons were made using mixed ANOVA with within subjects time factor and between subjects group factor, within subjects polynomial contrast, and independent t-test. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each group at test time one (initial testing), test time two (retesting period one), and test time three (retesting period two), and polynomial contrast allowed for the identification of the line or data trend as linear, quadratic, or cubic. Polynomial contrasts and post hoc test were only reported if the line trend or test was significant for participants’ data. Independent t-tests were used to compare the two groups at specific time periods, due to the fact that three groups were needed to perform post hoc test. Also due to participants not returning for retesting in the control group their scores were not considered during the group comparisons. Those deletions caused minor shifts in initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data. All participants returned for retesting in the treatment group.

For group comparison measurements of attitude, these groups’ initial testing and retesting measures were collected and compared for confidence, competence, and course
attitude. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted group participants’ attitude to compare the effects of the IV time on each DV including confidence, competence, and course attitude in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ confidence. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test were violated during this analysis. Results indicated a non-significant main effect of time, Wilk’s Lambda = 0.927, F(2, 35) = 1.380, p = 0.265, $eta^2 = 0.073$, observed power 0.277. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.990, F(2,35) = 0.184, p = 0.832, $eta^2 = 0.01$, observed power = 0.076. Confidence mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.950. Figure 4.12 shows confidence score mean measurements over time for both groups at each time period.
Figure 4.12 Control and Treatment Groups Confidence Mean Comparison - Shows the both treatment and control group’s confidence means overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ confidence in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 3.9328, SD = 0.4926) and treatment group (M = 4.2041, SD = 0.5413) conditions; t(36) = -1.599, p = 0.119 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 3.8655, SD = 0.5037) and treatment group (M = 4.0805, SD = 0.5527) conditions; t(36) = -1.240, p = 0.223 with a 95% confidence interval. In retesting period two, there was also not a significant difference in scores for the control group (M = 3.9832, SD = 0.5048) and treatment group (M = 4.1701, SD = 0.6188) conditions; t(36) = -1.003, p = 0.322 with a
95% confidence interval. Anova results support that there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in confidence.

A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ competence. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test was violated during this analysis. Results indicated a non-significant main effect of time, Wilk’s Lambda = 0.959, F(2, 35) = 0.745, p = 0.482, $\eta^2 = 0.041$, observed power 0.166. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.942, F(2,35) = 1.081, p = 0.350, $\eta^2 = 0.058$, observed power = 0.224. Competence mixed ANOVA comparison using time as the within subjects factor and group as a between factor was violated with Mauchy’s Test of Sphericity test at a significance level of 0.00005. Due to the violation of the sphericity assumption, the Greenhouse-Geisser correction was used for time, F(1.399, 50.353) = 1.201, p = 0.296, $\eta^2 = 0.032$, observed power = 0.215 and group, F(1.399, 50.353) = 1.385, p = 0.255, $\eta^2 = 0.037$, observed power = 0.242. Figure 4.13 shows competence score mean measurements over time for both groups for each time period.
Figure 4.13 Control and Treatment Groups Competence Mean Comparison - Shows the both treatment and control group’s competence means overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ competence in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 4.2059, SD = 0.4337) and treatment group (M = 4.1714, SD = 0.4971) conditions; t(36) = 225, p = 0.823 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 4.1765, SD = 0.4603) and treatment group (M = 4.2238, SD = 0.4647) conditions; t(36) = -0.314, p = 0.756 with a 95% confidence interval. In retesting period two, there was also not a significant difference in scores for the control group (M = 3.9824, SD = 0.7282) and treatment group (M = 4.2, SD = 0.4472) conditions; t(36) = -1.133, p = 0.265 with a 95%
confidence interval. The ANOVA results support that there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in competence. It was also noticed from initial testing to retesting period two that the treatment group increased compared to the control groups decrease which could possibly be in part to the intervention. There was also a widening gap in participants’ competence from retesting period one to retesting period with the treatment group having a higher mean than the control group. Even though there is a noticeable difference from the figure displaying the competence means there was no significant difference between the groups at each time period.

A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ course attitude. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test were violated during this analysis. Results indicated a non-significant main effect of time, Wilk’s Lambda = 0.993, F(2, 35) = 0.118, p = 0.889, eta² = 0.007, observed power 0.067. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.900, F(2,35) = 1.951, p = 0.157, eta² = 0.1, observed power = 0.377. Course attitude mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.684 Figure 4.14 shows course attitude mean measurements over time for both groups for each time period.
Figure 4.14 Control and Treatment Groups Course Attitude Mean Comparison - Shows the both treatment and control group’s course attitude means overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ course attitude in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 3.8449, SD = 0.3274) and treatment group (M = 3.9091, SD = 0.3056) conditions; t(36) = -0.623, p = 0.537 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 3.8396, SD = 0.3348) and treatment group (M = 3.9524, SD = 0.4092) conditions; t(36) = -0.915, p = 0.366 with a 95% confidence interval. In retesting period two, there was a significant difference in scores for the control group (M = 3.7754, SD = 0.3017) and treatment group (M = 4.0130, SD = 0.3417) conditions; t(36) = -2.244, p = 0.031 with a
95% confidence interval. The ANOVA results support that there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, and retesting period one. However, independent t-test did uncover a significant difference between the control and treatment groups during retesting period two in course attitude. Results from the mixed ANOVA analysis indicated that there was no interaction between time and group for course attitude with supporting evidence from independent t-test showing no significant difference during the initial testing period and retesting period one. Independent t-test did show a significant difference between groups during retesting period two where the treatment and control groups’ course attitude diverged significantly over time with the treatment group having a more positive course attitude than the control group.

For group comparison measurements of participant’s performance, these groups’ initial testing and retesting measures were collected and compared. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted on group participants’ performance to compare the effects of the IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ performance. Box’s Test of Equality of Covariance Matrices was not violated, and Levene’s Test of Equality of Error Variances was not violated during this analysis during initial testing and retesting period one. Levene’s Test of Equality of Error Variances did show a significance of 0.017 for retesting period two. This indicated that post hoc test or in this case independent t-test
need to be used to investigate why there was variability among group variances at retesting period two. Results indicated a non-significant main effect of time, Wilk’s Lambda = 0.970, F(2, 35) = 0.548, p = 0.583, $\eta^2 = 0.03$, observed power 0.133. However, the time main effect was qualified by a significant interaction between time and group, Wilk’s Lambda = 0.814, F(2,35) = 3.989, p = 0.028, $\eta^2 = 0.186$, observed power = 0.676. Performance mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.278. Figure 4.15 shows performance score mean measurements over time for both groups for each time period.

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period for performance. A two-tailed independent samples t-test was used to compare participants’ performance in
the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 46.1176, SD = 2.2046) and treatment group (M = 45.7143, SD = 2.5718) conditions; t(36) = 0.512, p = 0.612 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 45.4706, SD = 4.4176) and treatment group (M = 46.7619, SD = 3.4627) conditions; t(36) = -1.011, p = 0.319 with a 95% confidence interval. In retesting period two, Levene’s test for Equality of Variances was significant of 0.017, therefore equal variances were not assumed during this retesting period. Also for the retesting period two there was a significant difference in scores for the control group (M = 48.1176, SD = 2.0580) and treatment group (M = 45.0476, SD = 4.6204) conditions; t(28.839) = 2.729, p = 0.011 with a 95% confidence interval. The ANOVA results supported that there was an interaction between time and group on participants performance, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, and retesting period one. However, the independent t-test also identified that there was significant difference and variability of variance between groups retesting period two in performance. From initial testing to retesting period one the treatment group’s performance increased over the control group and although there was no significant difference between performances the intervention and moderate stress may had some influence in the increase. It is also important to consider the feedback given by the instructor directly after testing periods as an influencer, due to the nature of the topic of the research pertaining to a life-saving
procedure. The figure 4.15 also indicate a directionally opposite relationships between control and treatment groups during the performance analysis.

Group comparison measurements of participant’s knowledge, were collected and compared during these groups’ initial testing and retesting measures. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted on group participants’ knowledge to compare the effects of the IV time on the DV test score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ knowledge. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s Test of Equality of Error Variances was violated during this analysis. Results indicated a significant main effect of time, Wilk’s Lambda = 0.547, F(2, 35) = 14.515, p = 0.000026, eta² = 0.453, observed power 0.998. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.987, F(2,35) = 0.236, p = 0.791, eta² = 0.013, observed power = 0.084. Knowledge mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.835. Further analysis using polynomial contrasts indicate a significant linear trend over time, F(1,36) = 28.065, p = 0.000006, eta² = 0.438, observed power = 0.999. Additionally, post hoc test for time also showed a significance between initial testing and retesting period one with p = 0.001, and the initial testing and retesting period two with p = 0.000006. Figure 4.16 shows test score mean measurements over time for the both groups for each time period.
An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ test scores in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 93.1765, SD = 7.7155) and treatment group (M = 90.6667, SD = 4.2583) conditions; t(36) = 1.273, p = 0.211 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 88.4706, SD = 9.2609) and treatment group (M = 86.3810, SD = 7.5265) conditions; t(36) = 0.768, p = 0.448 with a 95% confidence interval. In retesting period two, there was no significant difference in scores for the control group (M = 86.8235, SD = 8.9179) and treatment group (M = 82.8571, SD = 8.1135) conditions; t(36) = 1.434, p = 0.160
with a 95% confidence interval. The ANOVA results supported that there was no interaction between time and group on participants knowledge; there also was a significant difference in the within subjects factor time for the control and treatment groups. Furthermore, the polynomial contrast showed a more linear trend, and supportive post hoc test distinguished significant differences between the initial testing and both retesting periods over time. However, the independent t-test demonstrated that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two. From initial testing to retesting period two both control and treatment groups’ knowledge decreased over time for both groups although there was no significant difference between knowledge at initial testing, retesting period one, and retesting period two times.

**Video Analysis**

Video analysis had an essential role in the identification of the effects of the virtual enhancement training, as well as documenting other issues that effected CPR performance which stayed prevalent throughout the study. The identification of these common mistakes varied among participants, but was committed repeatedly among participants. Common mistakes that were minor in performance seen throughout this study in both control and treatment groups involve the following: scene safety checks, pulse checks and duration of pulse checks, consciousness check, out of sequence, and compressions. An important observation of out of sequence procedures did not involve later processes in the CPR procedure beyond pulse checks; it was primarily related to calling 911, checking for consciousness, and checking the pulse. Some of the major and more prominent issues with the CPR procedure stood out such as calling 911, not sealing
the nose while giving breaths, head-tilt chin-lift technique with not pulling up on the
mandible, and hand placement. Initial testing video analysis, performance checks, and
instructor comments demonstrated that control group’s participants had issues with
sealing the nose and chest compressions. The treatment group experienced issues in
participants’ head-tilt chin-lifts and out of sequence procedure. During the retesting
period one, the control group showed issues with calling 911, sealing the nose, and being
out of sequence, but not with chest compressions. The treatment group had an issue with
being out of sequence. As the study concluded during retesting period two the control
had more participants that had issues with hand placement with participants placing their
hands lower than needed during compressions. The treatment group on the other hand
had issues with calling 911, not sealing the nose while giving breaths, head-tilt chin-lift
technique with not pulling up on the mandible, but they experienced little difficulty with
hand placement for compressions or being out of sequence. One rational explanation for
the treatment group could be related to the de-escalation of the emergency, supporting
surrounds, and experience. One thing was certain that participants had variability in
performance throughout the study. The major issues that were reported showed in a
minimum of 25 or more percent of participants, while minor issues at least stayed present
throughout the entire study period.

Although the video analysis was able to identify some issues that still remained
present in performing CPR among this study’s participants the primary purpose of the
video recording was to document the treatment groups responses to the enhance virtual
training in the mixed reality CPR emergency simulation. Since this was a major portion
of this study every treatment group participants’ reactions and deficiencies during
retesting period one (intervention) performance was documented within the appendix, and five examples of participant reactions are described below. This assisted in providing more of an observational analysis approach to understanding participants’ experience, and documenting it as they performed adult CPR in the mixed reality cardiac arrest emergency scenario.

**Participant #2.** Participant number 2 did not perform a pulse check of 5 to 10 seconds during CPR performance, and had an issue with worrying about the equipment while performing. The participant observed reactions were as follows:

> As soon as the scene started the participant rushed to the victim, and looked around then verbalized scene safety. The participant aggressively tapped the victim to check for consciousness, as well as having an elevated voice to call for 911 and an AED. Also the participant rushed the pulse check to immediately start chest compressions. A slight interruption occurred due to the tracker being detached while performing chest compressions and the participant reattached the tracker back to their waist before resuming compressions (The tracker equipment was used to determine the participant's position within the virtual environment.).

**Participant #14.** Participant number 14 had no issues with performance. The participant observed reactions were as follows:

> As soon as the scene started the participant quickly hopped to the victim, kneeled down and reached towards the victim, then jumped back up before touching the victim and verbalized, “Check to see if the scene is safe”. Then the participant quickly kneeled back down to check for consciousness of the victim. The participant started to make sure that the airway was open, but then quickly adjusted realizing the procedure had changed from A-B-C to C-A-B. Then started fast compressions and allowing the chest to recoil. The pinned equipment tracker fell, but did not distract the participant. The participant actually quickly rechecked for a pulse after the third cycle of compressions. The participant seemed immersed in the training scenario immediately after the scene started.

**Participant #18.** Participant number 8 did not check the scene for safety, check the pulse for 5 to 10 seconds, and call 911 or designate someone to do so during the CPR performance. The participant observed reactions were as follows:
The participant first looked around the scenario, therefore the participant did not verbalize that the scene was safe. The participant also did not see any virtual figure in the kitchen, so the participant did not consider asking someone or calling for 911. The participant also did not check for a cardiac pulse long enough, either he/she felt the urgent need to start compressions or forgot to perform hold for the pulse check. The participant said he/she did not notice anyone in the kitchen so she didn’t realize that we were still present and did not consider us as part of the scenario.

**Participant #19.** Participant number 19 had no issues with performance, and referred to the instructor to ask if she should keep going after the completion of the third cycle. The participant observed reactions were as follows:

The participant seemed excited once the scene came up. Immediately the participant started to check for consciousness of the victim then physically staggered and remembered to check the scene for safety. The participant did not check the pulse long enough to immediately began chest compressions. The participant barely made the cut off time for 5 cycles by less than 5 seconds before scene stopped. The Participant seemed very excited after training.

The participant commented, “I know. I was like whoa, wait a second this is really happening.”

Although the participant performed the call for 911 and check for responsiveness correctly during the simulation, the participant asked the instructor which one should you have completed first. The participant possibly could have performed the checks using instinct.

**Participant #21.** Participant number 21 did not check for scene safety and did call for 911 or designate someone to do so out of sequence during CPR performance. The participant observed reactions were as follows:

The participant seemed shocked in nervous upon entering the mixed reality simulation environment. The participant saw the virtual scene, quickly said, “Oh boy. Ok!” Even though the participant looked around before checking to see if the victim was response, the participant forgot to verbalize a check for scene safety. The participant checked for the victims pulse then stated, “You go get a ugh, you called the fire department and you go get an AED.” Instead of saying call 911. After the 2nd cycle the participant completed the cycle and stated, “Still nothing” in reference to the victim.
remaining unresponsive. The participant seemed eager after completing the performance.

The observation and documenting of these five participants alone showed that the virtual environment had some influence on performance, and these types of outcomes were observed in majority of the participants in the treatment group. It was also later observed that the participants reacted in a more relaxed manner during the initial testing and retesting period two when compared to retesting period one CPR performance with the intervention especially in the case of checking for scene safety.

**Outlier Identification and Group Comparisons**

In some studies there exist data points or extremes that heavily affect the final result when applying statistical analysis and these data points are called outliers. Outliers can have a drastic effect or influence on variable means during an analysis. Outliers have also been a controversial topic among research scientist as whether to delete, transform, or keep outlier data. In this study, it was decided to provide both the representation of the entire data set for each analysis and to show representation of without outliers influence. Due to the history of CPR having high variable measurements and retention in the areas of attitude, performance, and knowledge, it was safe to assume the possibility of having outliers within CPR studies. In this study outliers were identified and deleted based on the criteria of being at least three standard deviations or more away from the mean. The data was then reanalyzed for control and treatment group comparisons using descriptive statistics, mixed ANOVA, and independent t-test. This section was merely used to identify outliers within the study, and understand the significance of the effect or influence that these outliers have on study results.
Independent group comparisons were made using mixed ANOVA with within subjects time factor and between subjects group factor, within subjects polynomial contrast, and independent t-test. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each group at test time one (initial testing), test time two (retesting period one), and test time three (retesting period two), and polynomial contrast allowed for the identification of the line or data trend as linear, quadratic, or cubic. Polynomial contrasts and post hoc test were only reported if the line trend or test was significant for participants’ data. Independent t-tests were used to compare the two groups at specific time periods, due to the fact that three groups were needed to perform post hoc test. Participants that contained outlier data were not considered during the group comparisons. Those deletions caused minor shifts in initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data.

For group comparison measurements of attitude, these groups’ initial testing and retesting measures were collected and compared for competence. Outliers were only found within attitude measurements for competence in this study. Competence contained one participant that was identified as an outlier reducing the control group of participants to 16 and treatment group remained the same at 21. The outlier was then deleted before performing any analysis. All measures remained on the previously used scale for initial and retesting periods. Table 4.1 shows the SPSS descriptive statistics showing that all competence values are within three standard deviations of the mean.
Mixed ANOVA was conducted on group participants’ attitude to compare the effects of the IV time on the DV competence in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ competence. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test were violated during this analysis. Results indicated a non-significant main effect of time, Wilk’s Lambda = 0.992, F(2, 34) = 0.136, p = 0.873, eta² = 0.008, observed power 0.069. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.969, F(2,34) = 0.543, p = 0.586, eta² = 0.031, observed power = 0.132. Competence mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.112. Figure 4.17 shows competence score mean measurements without outliers over time for both groups for each time period.
Figure 4.17 Control and Treatment Groups Competence Mean Comparison without Outliers - Shows the both treatment and control group’s competence means without outliers overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ competence in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 4.20, SD = 0.4472) and treatment group (M = 4.1714, SD = 0.4971) conditions; t(35) = 0.181, p = 0.858 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 4.1563, SD = 0.4676) and treatment group (M = 4.2238, SD = 0.4647) conditions; t(35) = -0.437, p = 0.665 with a 95% confidence interval. In retesting period two, there was not a significant difference in scores for the control group (M = 4.1313, SD = 0.4045) and treatment group (M = 4.20, SD = 0.4472) conditions; t(35) = -0.482, p = 0.632 with a
95% confidence interval. The ANOVA results supported that there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in competence. For competence without the addition of outliers a change is shown in the profile of figure 4.17, otherwise there was no observations of any significance which was similar to the competence mean distributions with outliers. This may be due to the fact that there was only one outlier identified and deleted within participants’ attitude competence measures.

For group comparison measurements of performance, these groups’ initial testing and retesting measures were collected and compared for performance score. Outliers were found within both control and treatment groups. The control group contained two participants and the treatment group contained six participants that represented outliers in the study. All identified outliers were deleted reducing control group of participants to 15 and treatment group to 15 participants, and deletions occurred prior to performing any analysis. All measures remained on the previously used scale for initial and retesting periods. Table 4.2 shows the SPSS descriptive statistics showing that all performance values are within three standard deviations of the mean.

Table 4.2 Outlier Elimination - Performance Descriptive Statistics - Lists performance scores showing participants, minimum, maximum, mean, and standard deviation

<table>
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<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
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<td>41.00</td>
<td>48.00</td>
<td>46.2333</td>
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<tr>
<td>1 Week Later</td>
<td>30</td>
<td>43.00</td>
<td>50.00</td>
<td>47.5000</td>
<td>2.09680</td>
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<td>Performance</td>
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<td></td>
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</tr>
<tr>
<td>5 Week Later</td>
<td>30</td>
<td>42.00</td>
<td>50.00</td>
<td>47.5667</td>
<td>2.17641</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
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<tr>
<td>Valid N (listwise)</td>
<td>30</td>
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</tr>
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</table>
Mixed ANOVA was conducted on group participants’ performance to compare the effects of the IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ performance. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test were violated during this analysis. Results indicated a significant main effect of time, Wilk’s Lambda = 0.769, F(2, 27) = 4.061, p = 0.029, eta² = 0.231, observed power 0.672. However, the time main effect was qualified by a significant interaction between time and group, Wilk’s Lambda = 0.761, F(2,27) = 4.250, p = 0.025, eta² = 0.239, observed power = 0.693. Performance mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.921. Polynomial contrasts indicated a significant linear trend over time, F(1,28) = 7.093, p = 0.013, eta² = 0.202, observed power = 0.729. Post hoc test for time also showed a significance between initial testing and retesting period one with p = 0.024, and the initial testing and retesting period two with p = 0.013. Figure 4.18 shows performance score mean measurements without outliers over time for the both groups for each time period.
Figure 4.18 Control and Treatment Groups Performance Mean Comparison without Outliers - Shows the both treatment and control group’s performance means without outliers overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ performance in the initial training, retesting period one, and retesting period two in the control and treatment group conditions. In initial training, there was not a significant difference in scores for the control group (M = 45.8667, SD = 2.2318) and treatment group (M = 46.60, SD = 2.0284) conditions; t(28) = -0.942, p = 0.354 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 46.80, SD = 1.8205) and treatment group (M = 48.20, SD = 2.1778) conditions; t(28) = -1.910, p = 0.066 with a 95% confidence interval. In retesting period two, there was not a significant difference in scores for the control group (M = 48.2667, SD = 1.831) and
treatment group (M = 46.8667, SD = 2.3258) conditions; t(28) = 1.832, p = 0.078 with a 95% confidence interval. The ANOVA results support that there was an interaction between time and group on participants, and independent t-test assist in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in performance. There also was significance in within subject factor time, and there was not a significant affect with time with the analysis of performance that contained outliers. These results were supported by polynomial contrast and post hoc test that were not present in the analysis of performance with outliers. Additionally there was an increase in effect size and observed power during the mixed ANOVA analysis with no significance for the Levene’s Test of Equality of Error Variances. For performance without the addition of outliers a change is seen in the profile of figure 4.17 as well. It also shows only a positive trend for the control group from retesting period one to retesting period two. There was also a noticeable increase in the distance between means for control and treatment group for initial testing and retesting period one, and a decrease in the distance of mean at retesting period two with a non-significant independent t-test. Performance outlier deletions included the removal of eight participants from the study which had an influential effect on the different outcomes in performance with and without outliers.

For group comparison measurements of knowledge, these groups’ initial testing and retesting measures were collected and compared for test score. Outliers were found within both control and treatment groups. The control group contained one participant and the treatment group contained three participants that represented outliers in the study. All identified outliers were deleted reducing the control group of participants to 16 and
treatment group remained to 18 participants, and deletions occurred prior to performing any analysis. All measures remained on the previously used scale for initial and retesting periods. Table 4.3 shows the SPSS descriptive statistics showing that all test score values are within three standard deviations of the mean.

**Table 4.3 Outlier Elimination - Knowledge Descriptive Statistics - Lists knowledge test scores showing participants, minimum, maximum, mean, and standard deviation**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Testing</td>
<td>34</td>
<td>84.00</td>
<td>100.00</td>
<td>92.5882</td>
<td>4.93668</td>
</tr>
<tr>
<td>1 Week Later Retesting</td>
<td>34</td>
<td>76.00</td>
<td>100.00</td>
<td>88.5882</td>
<td>6.23829</td>
</tr>
<tr>
<td>5 Week Later Retesting</td>
<td>34</td>
<td>72.00</td>
<td>96.00</td>
<td>86.3529</td>
<td>6.61441</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mixed ANOVA was conducted on group participants’ knowledge to compare the effects of the IV time on the DV test score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ knowledge. Neither Box’s Test of Equality of Covariance Matrices nor Levene’s test of Equality of Error Variances for retesting period one and two were violated during this analysis. Although Levene’s test did show a significant difference of 0.047 for the initial testing period, in which post hoc or independent t-test was used to identify specific times in which the variability occurred. Results indicated a significant main effect of time, Wilk’s Lambda = 0.458, F(2, 31) = 18.323, p = 0.000006, eta² = 0.542, observed power 1.0. However, the time main effect was not qualified by a significant interaction between time and group, Wilk’s Lambda = 0.993, F(2,31) = 0.111, p = 0.896, eta² = 0.007, observed power = 0.065.
Performance mixed ANOVA comparison using time as the within subjects factor and group as a between subjects factor was not violated with Mauchy’s Test of Sphericity test at a significance level of 0.207. Polynomial contrasts indicate a significant linear trend over time, $F(1,32) = 30.508$, $p = 0.000004$, $\eta^2 = 0.488$, observed power = 1.0. Post hoc test for time also showed a significance between initial testing and retesting period one with $p = 0.00037$, and the initial testing and retesting period two with $p = 0.000004$.

Figure 4.19 shows test score mean measurements without outliers over time for the both groups for each time period.

![Graph showing estimated marginal means of group comparison test without outliers](image)

**Figure 4.19** Control and Treatment Groups Knowledge Mean Comparison without Outliers - Shows the both treatment and control group’s test score means without outliers overtime

An independent samples t-test was also used to further investigate the results provided by the mixed ANOVA analysis between groups at each time period. A two-tailed independent samples t-test was used to compare participants’ knowledge in the initial training, retesting period one, and retesting period two in the control and treatment group.
conditions. In initial training, Levene’s Test for Equality of Variances had a significant value of 0.047 indicating that equal variances were not assumed. Also there was a significant difference in scores for the control group (M = 94.50, SD = 5.6332) and treatment group (M = 90.8889, SD = 3.5792) conditions; t(24.871) = 2.20, p = 0.037 with a 95% confidence interval. In retesting period one, there was not a significant difference in scores for the control group (M = 90.00, SD = 7.0048) and treatment group (M = 87.3333, SD = 5.3578) conditions; t(32) = 1.235, p = 0.219 with a 95% confidence interval. In retesting period two, there was not a significant difference in scores for the control group (M = 88.25, SD = 6.934) and treatment group (M = 84.6667, SD = 6.0196) conditions; t(32) = 1.615, p = 0.116 with a 95% confidence interval. The ANOVA results supported that there was no interaction between time and group on participants, which shows similarity with no significant interaction for the knowledge analysis with outliers, and independent t-test assist in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in knowledge. However, there was a significant difference between groups at initial testing, which differs from the knowledge initial testing independent t-test with test scores containing outliers. There also was significance in within subject factor time similar to the analysis of performance that contained outliers. These results were supported by the polynomial contrast and post hoc test that were not present in the analysis of knowledge with outliers. Additionally there was an increase in effect size and observed power during the mixed ANOVA analysis for the within subjects variable time, and significance for the Levene’s Test of Equality of Error Variances for the initial testing period. For knowledge without the addition of outliers little change was seen in
the profile of figure 4.18. It also showed only a declining trend for the control group and treatment groups from retesting period one to retesting period two. Knowledge outlier deletions included the removal of four participants from the study which had an influential effect on the different outcomes in knowledge with and without outliers.
Chapter 5

DISCUSSION

This study examined the use of CPR training techniques and the uses of virtual reality. The major themes discussed in this study related to CPR are traditional CPR training, CPR traditional education, attitude, performance, simulation and technology for CPR training, and skills and retention of CPR. The major themes in relation to virtual training are virtual reality simulation and environments, and virtual reality in education. The major findings in literature support the evidence of lack of retention in CPR knowledge, poor quality CPR performance by layperson as well as medical personnel, inadequate overall CPR performance during scenario simulations, conflicting attitudes among trainees, and the need to find better methods of training to enhance retention and overall CPR performance during resuscitation attempts. Additionally major literature related findings for virtual reality suggest that it has possible uses in education, enhances self-efficacy, confidence, and performance through repeat learning; it can also be used as a tool to simulate complex procedures quickly and efficiently. Therefore, the purpose of this study was to test the use and effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training at a southeastern major university. This research was used to evaluate the retention of CPR attitude, performance, and knowledge of pre-nursing students following the School of Nursing academic curriculum, and the use of
virtual reality as an enhancement tool to prepare students for possible real world out-of-hospital experiences.

The significance of this proposed study was its contribution to both CPR and virtual reality areas. It provided a new innovative training approach for CPR candidates, as well as providing more information on the effects and use of virtual reality as an educational training tool. Additionally recent changes in the CPR guidelines by the AHA were also measured to assess the trainee’s adaptation to the new 2010 resuscitation guidelines in a simulated out-of-hospital environment. These assessments were used to answer the primary research questions of this study which are: 1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? 2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? 3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? 4) What effect does time have on the retention of CPR participants between the control and treatment groups?

**Study Preparations**

Preparatory measures of this research study included the development of a mixed reality simulation environment for out-of-hospital cardiac arrest emergency scenarios and pilot testing. This study focused on using stereoscopic display technology and CPR training to reproduce various geometries with depth within the Viscube system to possibly improve students’ retention of knowledge and performance for CPR as well as evaluate their attitude towards CPR training. The process required the use of multiple software and coding libraries to gain the sensation of experiencing a 3D mixed reality
environment that replicates an out-of-hospital cardiac arrest scenario. Coding libraries that were used are OpenGL and SDL which provided libraries to display geometrical objects. SDL mixer is a subcomponent of SDL that was used to produce event handles and provide sound sources. The coding language for this research was primarily done using C++, which is an object oriented programming language. Other software or libraries that were used in the creation of the CPR training simulation were Blender and FreeVR. Hardware used in this study included a Linux machine, the Viscube C4-SX Multi-Screen Immersive 3D display system, and a fogger machine model FM-1000. The virtual component of the mixed reality simulation was tested during a pilot prior to the main study that was conducted the following Fall semester.

Pilot study testing consisted of a control and treatment group comparison during the summer semester. The primary goal of the study was to test the virtually enhanced training while only providing a virtual representation of the out-of-hospital cardiac arrest environment, and evaluate the research design and materials used for data collection. The pilot study contained a control and treatment group that was later compared to determine the impact of virtually enhanced training. The pilot’s statistical analysis involved descriptive statistics, and repeated measures and independent t-test during a two testing time periods. Evaluations from the pilot study showed that there was no difference in initial testing for both the control and treatment group. Results demonstrated that study participants received the virtual environment well, as well as demonstrating an increase although non-significant in final performance among treatment participants after experiencing a clam virtually enhanced environment with no distractions. Other conclusions that were drawn were the following: to use an ANOVA
design instead of t-test to gain a better baseline and after intervention measurements as well as determine the influence of the intervention. Using the same test would provide better results for knowledge measurements, and to consider outliers and the impact of instructor feedback on participants’ performance outcomes during the study’s training conditions. Finally, it supported the expert validation and reliability testing of both the newly developed survey and performance instruments.

**Main Study**

**Main Study Design**

During the main study of this research an ANOVA design was implemented using the development of a mixed reality simulation as well as documenting statistical analysis on two groups of CPR participants to detect retention and change in participants’ attitude, performance, and knowledge over a five week duration to address the research questions of this study. The design was applied to both the control and treatment groups during this research study at three different time periods. It placed emphasis on descriptive statistics, independent t-test, and repeated measures and mixed ANOVA for statistically analysis. Descriptive statistics were used to analyze and assist in understanding the distribution of data in all testing periods for both repeated measures and mixed ANOVA analysis. Repeated measures analysis with time as a within subjects factor allowed for the detection of changes within each group of participants from the initial testing, retesting period one, and retesting period two. Mixed ANOVA with within subjects time factor and between subjects group factor, within subjects polynomial contrast, and independent t-test were used to detect changes between groups during all testing periods of the study.
Examining Test Results

Descriptive statistics primary usages during this study were to identify group minimums, maximums, range, means, standard deviations, and visualize the distribution of the data set. They allowed for an interpretation of the data based on frequency analysis, which elaborated on relative positioning of the samples based on percentages and the criteria’s measurement scale. They also assisted in the identification and deletion of outlier data points that influenced the final interpretation of statistical analysis for this research design.

Repeated Measures Analysis

Test retest comparisons were made using repeated measures ANOVA with polynomial contrast for the control and treatment group. Repeated measures t-test was also used to determine the influenced of the treatment group’s intervention when returning back into the traditional classroom setting. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each student at test time one (initial testing), test time two (retesting period one), and test time three (retesting period two), and polynomial contrast allowed for the identification of the line or data trend as linear, quadratic, or cubic. Polynomial contrasts and post hoc test were only mention if the line trend or test was significant for participants’ data. Also due to participants not returning for retesting their scores were not considered during the test retest comparison. Those deletions caused minor shifts in initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data.
**Attitude.** The control group’s repeated measures results only utilized repeated measures ANOVA and the results pertaining to attitude, performance and knowledge retention are as follows. Attitude results indicated that there was a trending decline in control group participants’ competence, and course attitude with the exception of confidence; although there was no significant difference found in participants’ confidence, competence, and course attitude over time.

The treatment group’s repeated measures results only utilized repeated measures ANOVA and t-test, and the results pertaining to attitude, performance and knowledge retention are as follows. Results indicated that there was a slight increase in treatment group participants’ competence, and course attitude with the exception of confidence from the initial testing period to the intervention in retesting period one. From retesting period one to retesting period two confidence and course attitude experienced a slight increase, but competence experience a slight decrease in attitude. Although there were fluctuations among participants’ confidence, competence, and course attitude there was no significant difference found among the three over time. Additionally the use of the intervention for attitude from virtual training showed a slight increase between retesting period one and two. Although the increase was non-significant it did show a slight increase in attitude towards virtual training after participants were returned to a traditional classroom setting for the final testing.

Attitude results for both groups did reflect trends stated by previous literature. In the case of the control group there were noticeable declines in attitude from viewing the related figures especially for competence and course attitude for pre-nursing students (Hamasu, et al., 2009; Makinen, Niemi-Murola, & M. Kaila, 2009; Niemi-Murola,
Makinen, & Castren, 2007). The exception in attitude among the control group was confidence. From the initial testing to retesting period one, confidence declined but after being retested the second time there was an increase in confidence among participants. The treatment group also experienced a similar trend in confidence, and this may be due in part to having three testing periods, which gave participants more experience with the CPR procedure. The treatment group’s competence and attitude differed from that of the control group. From initial testing to retesting period one the treatment group’s participant’s experienced an increase in competence which may have been related to the intervention, and after returning to the traditional setting a decline in competence was recorded. Course attitude showed a similar trend demonstrated in previous CPR literature studies in the control group that indicated a decrease in course attitude as time progressed (Hamasu, et al., 2009; Makinen, Niemi-Murola, & M. Kaila, 2009; Niemi-Murola, Makinen, & Castren, 2007). The treatment group’s course attitude experienced an increase from the initial testing period to retesting period one, and another positive increase from retesting period one to retesting period two. The treatment group’s attitude results reemphasized the possible improvements that can be made by using technology to positively reinforce a complicated process like CPR by improving its educational outlook among participants (Canche, Narvaez, Chi, & Lianes, 2011; Creutzfeldt, Hedman, Medin, Heinrichs, & Fellander-Tsai, 2010). Also the treatment group’s intervention of the usage of a mixed reality out-to-hospital cardiac arrest emergency had an association with a positive attitude, and furthermore the attitude slightly increased after participants were reintroduced back into the traditional setting. Although the increase was not significant it did assist in showing that virtual enhancement CPR training was well received when
compared to traditional CPR training in further support of the use of virtual reality as an educational tool (Semeraro, Frisoli, Bergamasco, & Cerchiari, 2009; Lombardi, 2007; Pan, Cheok, Yang, Zhu, & Shi, 2006).

**Performance.** Performance results for both groups reflected trends reported by previous CPR and virtual reality literature, and in some cases contradicted the literature (Christenson, et al., 2007; Wilkerson, Avstreih, Gruppen, & Beier, 2008; Vincent, Sherstuk, Burgess, & Connolly, 2008). The control group results indicated that there was a significant change in performance primarily between the initial testing period and retesting period one when compared to retesting period two. The results indicated a slight decline in participants’ performance from the initial testing to retesting period one, and an increase in participants’ performance after retesting period one to retesting two. After the control group’s retesting period one there was a significant increase in performance which is contrary when compared to other accounts of literature, but it does support performance improvements due to retesting (Christenson, et al., 2007; Woollard, et al., 2004). The treatment group results indicated that there was not a significant change in performance throughout the initial testing period, retesting period one, and retesting period two. The results indicated a slight increase in participants’ performance from the initial testing to retesting period one, and a slight decrease in participants’ performance after retesting period one to retesting two. The increase in the treatment group’s performance during retesting period one could be related to the usage of the virtual enhancement, but the decrease in performance showed a decline after being reintroduced into the traditional classroom environment (Pan, Cheok, Yang, Zhu, & Shi, 2006; Semeraro, Frisoli, Bergamasco, & Cerchiari, 2009). This helps demonstrate Laila
Arnesdatter Hopstock conclusion of having a more relatable or familiar environment pertaining to the task at hand which could have a positive effect on outcomes (2008). The mixed reality out-of-hospital cardiac arrest scenario was also considered more realistic by participants that experienced the intervention in relation to a CPR emergency; therefore from attitudes towards virtual training responses, the virtual enhancement intervention seemed more relatable. After each performance procedure, there was a need to take into account feedback given by the instructor. Due to this study being performed on a life-saving technique it would be unethical and against CPR instructor’s professional conduct to not provide corrective feedback on participants with less than acceptable performance, and the instructor’s feedback may have had some influence on participants’ performance. It is also important to consider the anxiety or stress levels of control and treatment group participants during testing. The treatment group’s intervention may have placed them in a heighten state to increase performance, but due to feedback being given directly after performing CPR it may also lowered their ability to mentally retain those corrections given. This could have been possibly related to the participant’s individual response whether fear or anxiety could have effects on memory, attention, and performance, and fear and anxiety have been prominent in previous CPR literature. Therefore there is a need for further investigations on the uses of virtual enhancement technologies to fully understand their impact on learning and performing of task, as well as determining the impact of virtually enhanced simulations without instructor feedback (Ewy & Sanders, Alternative approach to improving survival of patients with out-of-hospital primary cardiac arrest, 2012; Nolan, et al., 2010; Corley & Lejerskar, 2003;
Wilkerson, Avstreih, Gruppen, & Beier, 2008; Vincent, Sherstyuk, Burgess, & Connolly, 2008).

**Video Analysis.** CPR performance can be difficult to understand when considering how and why a participant performed a particular way, so this study included video recording to assist in documentation of participants actions during all testing periods. During initial testing and retesting period two video recording was primarily used to identify common mistakes among participants, and the major interest pertained to retesting period one for the treatment group. Since video recordings did not have any statistical or numerical value it was only detailed observations were reported. However, it provided essential information in understanding the impact of the virtual enhanced training. Information discussed was primarily from observing the recorded video of participants performing CPR during the treatment group’s intervention.

The observations and documenting of these treatment participants showed that the virtual environment had some influence on performance, and these types of outcomes were observed in majority of the participants in the group. It was also later observed that the participants reacted in a more relaxed manner during the initial testing and retesting period two when compared to retesting period one CPR performance with the intervention especially in the case of checking for scene safety. This assisted in providing more of an observational analysis approach to understanding participants’ experience, and documenting it as they performed adult CPR in the mixed reality cardiac arrest emergency scenario, and additionally identified some minor and major issues that were present within participants CPR performance (Woollard, et al., 2004; Christenson, et al., 2007).
Knowledge. Knowledge results for both groups did reflect trends stated by previous literature. Control group’s results indicated that there was a significant change in test scores primarily between the initial testing period when compared to retesting period one and retesting period two. The results indicated a significant decline in participants’ knowledge from the initial testing to retesting period one, and a slight decrease in participants’ knowledge after retesting period one to retesting two. The results were also further supported by a significant linear trend from polynomial contrast, and an identified significance between the initial testing period and retesting period two by post hoc test. The treatment group’s results indicated that there was a significant change in test scores primarily between the initial testing period and retesting period two. The results indicate a decrease in participants’ knowledge from the initial testing to retesting period one, and a slight decrease in participants’ knowledge after retesting period one to retesting two. The results are also further supported by a significant linear trend from polynomial contrast, and an identified significance between the initial testing period and retesting period two by post hoc test also. In reference to literature both control and treatment groups had significant decreases in knowledge over a five week duration further supporting the lack of retention in CPR knowledge (Christenson, et al., 2007; Ertl & Christ, 2007; Mahony, Griffiths, Larsen, & Powell, 2008; Parnell & Larsen, 2007). The treatment group did manage to show resistance to a significant decrease in knowledge between the initial testing to retesting period one and two, while the control group showed an immediate and significant decrease from initial testing to retesting period one which could have been due to the different training approaches (Arntz, 2011; Ertl & Christ, 2007; Hunziker, et al., 2011; Lynch, et al., 2005; Parnell & Larsen, 2007).
Independent Group Comparison Analysis

Independent group comparisons were made using mixed ANOVA with within subjects time factor and between subjects group factor, within subjects polynomial contrast, and independent t-test. This type of statistical analysis allowed for the measurement of attitude, performance, and knowledge based on reevaluating and comparing each group at test time one (initial testing), test time two (retesting period one), and test time three (retesting period two), and polynomial contrast allowed for the identification of the line or data trend as linear, quadratic, or cubic. Independent t-tests were used to compare the two groups at specific time periods, due to the fact that three groups were needed to perform post hoc test. Also due to participants not returning for retesting their scores were not considered during the group comparisons. Those deletions caused minor shifts in initial testing results for attitude, performance, and knowledge pertaining to descriptive statistical data.

Attitude. For group comparison measurements of attitude, these groups’ initial testing and retesting measures were collected and compared for confidence, competence, and course attitude. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted group participants’ attitude to compare the effects of IV time on each DV including confidence, competence, and course attitude in initial testing, retesting period one, and retesting period two conditions. Confidence comparisons between the two groups’ results supported there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in confidence.
Competence comparisons between the two groups’ results supported there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in competence. It was also noticed from initial testing to retesting period two that the treatment group increased compared to the control groups decrease which could possibly be in part to the intervention. There was also a widening gap in participants’ competence from retesting period one to retesting period with the treatment group having a higher mean than the control group. Course attitude comparisons between the two groups’ results supported there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, and retesting period one. Independent t-test did uncover a significant difference between the control and treatment groups during retesting period two in course attitude. Results from the mixed ANOVA analysis indicated that there was no interaction between time and group for course attitude with supporting evidence from independent t-test showing no significant difference during the initial testing period and retesting period one. Independent t-test did show a significant difference between groups during retesting period two where the treatment and control groups’ course attitude diverged significantly over time with the treatment group having a more positive course attitude than the control group. In comparing the attitude analysis between the two groups it was seen that there was no interaction between time and group for attitude, but there were noticeable distinctions that were recorded. In category of confidence, the treatment means remained higher than the control group, although differences were not
significantly different. In the case of competence the treatment group means were higher than the control group beginning at retesting period one (intervention) and leading through to retesting period two. It was also noticed that the control group had experienced a far greater decline in competence than the treatment group after the final retesting. Course attitude between both groups completely diverged with the treatment group experiencing positive increases in attitude while the control group’s attitude experienced a decline. Course attitude also contained a widening difference between control and treatment groups that displayed significant results over the study, and may have been due to the intervention.

**Performance.** Group comparison measurements of participant’s performance, these groups’ initial testing and retesting measures were collected and compared. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted for group participants’ performance to compare the effects of the IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ performance. ANOVA results supported that there was an interaction between time and group on participants performance, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, and retesting period one. Independent t-test also identified that there was significant difference and variability of variance between groups for retesting period two in performance. From initial testing to retesting period one the treatment group’s performance increased over the control group and although there was no significant difference between performances the intervention and
moderate stress may have had some influence in the increase. It is also important to consider
the feedback given by the instructor directly after testing periods as an influencer, due to
the nature of the topic of the research pertaining to a life-saving procedure. The control
group had lower means than the treatment group at the retesting one period which
implied that they received more corrections and feedback for their performance from the
instructor, which could increase their final performance; therefore the instructor’s
feedback may have had some influence on participants’ performance. These results also
indicated a directionally opposite relationships between control and treatment groups
during the performance analysis. Additionally, the influence of having and not having
distractions during the mixed reality simulations for the pilot and main studies showed an
increase in final performance when practicing in a calm mixed reality environment after
returning to a similarly calm traditional classroom environment. Alternatively, the use of
distractions with virtually enhanced training showed a decrease in performance after
participants demonstrated their CPR procedure in a calm environment (retesting two
period) with previously experiencing a more dramatic training simulation (retesting one
period). This also promotes the need for further investigation of the influence of virtually
enhanced training when in combination with relevant environment distractions to
determine the full impact of mixed reality simulations.

Knowledge. These group’s initial testing and retesting measures were collected
and compared for group comparison measurements of participant’s knowledge. All
measures remained on the previously used scale for initial and retesting periods. Mixed
ANOVA was conducted for group participants’ knowledge to compare the effects of th
IV time on the DV test score in initial testing, retesting period one, and retesting period
two conditions. A mixed ANOVA was conducted to assess whether there were time and
group differences in CPR participants’ knowledge. ANOVA results supported that there
was no interaction between time and group on participants knowledge; there also was a
significant difference in the within subjects factor time for the control and treatment
groups. Polynomial contrast showed a more linear trend, and supportive post hoc test
distinguished significant differences between the initial testing and both retesting periods
over time. Independent t-test demonstrated that there was no significant difference
between groups at specific testing times of initial testing, retesting period one, and
retesting period two. From initial testing to retesting period two both control and
treatment groups’ knowledge decreased over time for both groups although there was no
significant difference between knowledge at initial testing, retesting period one, and
retesting period two times. Typically during many simulations with a focus on
performance there is minor reflection on knowledge during performance especially in the
case of CPR. Therefore there is a need to further investigate ways to implement
knowledge into simulations to provide a greater emphasis on knowledge and
performance, as well as attempting to improve knowledge retention by having a higher
degree of association between knowledge and performance during simulations.

**Outlier Influence**

In some studies there exist data points or extremes that heavily affect the final
result when applying statistical analysis and these data points are called outliers. Outliers
can have a drastic effect or influence on variable means during an analysis. Outliers have
also been a controversial topic among research scientist as whether to delete, transform,
or keep outlier data. In this study, it was decided to provide both the representation of the
entire data set for each analysis, and also to show representation of without outliers influence. Due to the history of CPR having high variable measurements and retention in the areas of attitude, performance, and knowledge, it was safe to assume the possibility of having outliers within CPR studies. In this study outliers were identified and deleted based on the criteria of being at least three standard deviations or more away from the mean. The data was then reanalyzed for the control and treatment group comparisons using descriptive statistics, mixed ANOVA, and independent t-test. The purpose of identifying outliers within the study was to understand the significance of the effect or influence that these outliers have on study results.

**Attitude Outliers and Analysis.** Group comparison measurements of attitude analyzed the groups’ initial testing and retesting measures to compared for competence. Outliers were only found within attitude measurements for competence in this study. Competence contained one participant that was identified as an outlier reducing the control group of participants to 16 and treatment group remained the same at 21. The outlier was then deleted before performing any analysis. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted on group participants’ attitude to compare the effects of the IV time on the DV competence in initial testing, retesting period one, and retesting period two conditions. ANOVA results supported there was no interaction between time and group on participants, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in competence. For competence without the addition of outliers a change was shown in the profile of figure 4.17, otherwise there was no observations of any significance
which was similar to the competence mean distributions with outliers. This may be due to the fact that there was only one outlier identified and deleted within participants’ attitude competence measures. The control group’s profile changed to demonstrate a steep declining slope from the initial testing period to retesting period one with the widening difference becoming evident one week after initial testing compared to the previous five weeks without outliers. Although the deletion of one outlier did not carry any significant effect, it did manage to completely change the profile of the mean data for the control group’s competence. This could also have led to a different interpretation of the data over time if the study went on for more than five weeks, which could eventually lead to different conclusions than the previous data.

**Performance Outliers and Analysis.** For group comparison measurements of performance, the groups’ initial testing and retesting measures were collected and compared for performance score. Outliers were found within both control and treatment groups. The control group contained two participants and the treatment group contained six participants that represented outliers in the study. All identified outliers were deleted reducing the control group of participants to 15 and treatment group remained to 15 participants, and deletions occurred prior to performing any analysis. All measures remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted on group participants’ performance to compare the effects of the IV time on the DV performance score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ performance. ANOVA results supported that there was an interaction between time and group on participants, and independent t-test
assisted in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in performance. There also was significance in within subject factor time, and there was not a significant affect with time with the analysis of performance that contained outliers. These results were supported by polynomial contrast and post hoc test that were not present in the analysis of performance with outliers. Additionally there was an increase in effect size and observed power during the mixed ANOVA analysis with no significance for the Levene’s Test of Equality of Error Variances. For performance without the addition of outliers a change is seen in the profile of figure 4.18 as well. It also shows only a positive trend for the control group from retesting period one to retesting period two. There is also a noticeable increase in the distance between means for control and treatment group for initial testing and retesting period one, and a decrease in the distance of mean at retesting period two with a non-significant independent t-test. Performance outlier deletions included the removal of eight participants from the study which had an influential effect on the different outcomes in performance with and without outliers.

Knowledge Outliers and Analysis. Group comparison measurements of knowledge between groups’ initial testing and retesting measures were collected and compared for test scores. Outliers were found within both control and treatment groups. The control group contained one participant and the treatment group contained three participants that represented outliers in the study. All identified outliers were deleted reducing the control group of participants to 16 and the treatment group remained to 18 participants, and deletions occurred prior to performing any analysis. All measures
remained on the previously used scale for initial and retesting periods. Mixed ANOVA was conducted on group participants’ knowledge to compare the effects of the IV time on the DV test score in initial testing, retesting period one, and retesting period two conditions. A mixed ANOVA was conducted to assess whether there were time and group differences in CPR participants’ knowledge. ANOVA results supported that there was no interaction between time and group on participants, which is opposite of the significant interaction for the knowledge analysis with outliers, and independent t-test assist in showing that there was no significant difference between groups at specific testing times of initial testing, retesting period one, and retesting period two in knowledge. However, there was a significant difference between groups at initial testing, which differs from the knowledge initial testing independent t-test with test scores containing outliers. There also was significance in within subject factor time similar to the analysis of test scores that contained outliers. These results were supported by polynomial contrast and post hoc test that were not present in the analysis of knowledge with outliers. Additionally there was an increase in effect size and observed power during the mixed ANOVA analysis for the within subjects variable time, and significance for the Levene’s Test of Equality of Error Variances for the initial testing period. For knowledge without the addition of outliers little change was seen in the profile of figure 4.19. It also showed only a declining trend for the control group and treatment groups from retesting period one to retesting period two. Knowledge outlier deletions included the removal of four participants from the study which had an influential effect on the different outcomes in knowledge with and without outliers.
Answering Research Questions

The main purpose of this study was to test the use and effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training, and the following research questions were used to draw conclusions based on measuring the specific criteria of CPR training such as retention with respect to knowledge, performance, attitude, and time.

1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? There were no significant improvements on knowledge from this study. Knowledge examinations remained consistent with previous literature pertaining to CPR knowledge retention studies. Frequency analysis indicated that both the control and treatment groups had a high percentage of inadequate participants that failed the knowledge test by the end of the study. The control group had 17.6 percent that failed during the initial testing, 35.3 percent during the one week later retesting, and 41.2 percent failed during the final retesting. The treatment group experienced failures with 9.5 percent, 38.1 percent, and 71.4 percent in the initial testing, one week later retesting, and the final retesting. Evidence from this data shows that both groups experienced high failure rates during the knowledge examinations during this study. Of all 38 participants only 42.1 percent were able to pass the CPR examinations with a score of 88 out of 100 after five weeks. Although the use of virtual reality environmental training did not assist in improving CPR knowledge of the participants; there still may be methods available to use virtual reality for knowledge purposes even within CPR. This study’s greatest influence of
virtual reality was directed towards the performance environment; therefore the possibility of using virtual reality to enhance CPR learning or any other learning cannot be overruled. As for evidence of retention, during repeated measure ANOVA analysis the treatment group showed no significant decrease from initial testing to retesting period one, and from retesting period one to retesting period two therefore showing some degree of retention. The control group on the other hand immediately experienced a significant decrease in participants’ knowledge from the initial testing period one to retesting period one, and experienced no significant decrease from retesting period one to retesting period two. Therefore it can be concluded that virtual enhanced training did show some degree of knowledge retention during the intervention (retesting period one), as well as having no significant decreases in knowledge from retesting period one to retesting period two for participants in the treatment group. Although the treatment did not experience a significant decrease in knowledge, both control and treatment group experienced significant decreases in knowledge from initial testing to the final retesting. Also identifying and deleting outliers during the knowledge study yielded similar results to the analysis that included them.

2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? The control group did experience a significant change in performance after retesting period one. The control group’s performance ranged from 45 to a little above 48 out of 50, demonstrating retention of performance skills. There were no significant improvements in training due to virtual training, although there were improvements in performance during the intervention and no significant reductions in performance over the duration of the study. Treatment
group’s participants stayed within a range that was not considered a significant change from initial testing to retesting period one, from retesting period one to retesting period two, and from initial testing to retesting period two. Means remained within the range of 45 to 47 out of 50 throughout the entire study demonstrating performance retention. During the intervention time period of the study the treatment group outperformed the control group, although there was no significant difference in performance among both groups during retesting period one. The influence of the instructor and training conditions had to be considered during this study due to the instructor providing feedback directly after the CPR procedure performance. This may have had an impact on performance which resulted in a sudden increase of performance for the control group during retesting period two. Due to the stressful situation placed upon the treatment group during retesting period one, they may not have been able to retain information as well as the control group. This may have led to the control group’s performance being significantly greater than that of the treatment group during retesting period two. Additionally, reanalysis with the identification and elimination of outliers during the performance analysis indicated that there were no significant differences between the performance of the control and treatment group. This demonstrates two different outcomes of performance with one concluding that there was retention of performance over time in both groups with a significant difference at the final retesting, and the other demonstrating no differences between the two groups during the duration of the study. The analysis pertaining to the usage of outliers within the data set indicates that the control group outperformed the treatment group during initial testing, and significantly during retesting period two, but not during retesting period one (intervention). Analysis
without outliers indicated that the treatment group outperformed the control group during both initial and retesting period one although not significantly, and there was no significant difference in retesting period two in the control groups favor. This demonstrates the significance of outliers and their influence on this study, in which whether they are considered or not considered yields two very different outcomes. Additionally, the video analysis further supports that the virtual enhancement training did have some observationally observed effect on participants performance, but when statistically compared there was no significant difference during the intervention testing period (retesting period one) between the control and treatment groups. This implied that an observational effect was observed in participants’ reactions and responses during the mixed reality simulation which demonstrated an observational difference during the testing period of the control and treatment group. However, there was not enough statistical power between the treatment group and control group performance scores to conclude a mathematically significant difference

3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? Attitude comparisons varied among both groups over the study duration, but in most cases such as initial testing and retesting period one there was no significant difference in attitude among the groups. It was noticed that typically the treatment group’s means were higher as the study progressed when compared to the control group’s means. In comparing the attitude analysis between the two groups it was seen that there was no interaction between time and group for attitude for confidence, competence, and course attitude, but there were noticeable distinctions that were recorded. In category of confidence the treatment group means remained higher than the
control group, although differences were not significantly different. In the case of competence the treatment group means were higher than the control group beginning at retesting period one (intervention) and leading through retesting period two. It was also noticed that the control group had experienced a far greater decline in competence than the treatment group after the final retesting. Course attitude between both groups completely diverged with the treatment group experiencing positive increases in attitude while the control group’s attitude experienced a decline. Course attitude also contained a widening difference between control and treatment groups that displayed significant results over the study, and may have been due to the intervention. These results support the possibility of there also becoming a significant different over time in more than course attitude. The treatment group’s course attitude showed positive significant results when compared to the control group’s course attitude, and that may be from positive feedback received from participant’s virtual enhancement training period. This study did conclude that overall the treatment group’s participants displayed better attitudes whether by providing higher means over time that were non-significant, but could have the possibility of becoming significant as time progresses, and the significance that did occur in course attitude. Also the exclusion of outlier data further supports the widening gap in competence as time progressed throughout the study. Further investigation of the effects of virtual reality usages needs to be done to identify if there will be a significant effect in attitude for all attitude measurements over a longer period of time. That will assist in determining if virtual reality can provide long term or even permanent positive effects on participants’ attitudes towards CPR.
4) What effect does time have on the retention of CPR participants between the control and treatment groups? The effects of time for both groups showed no interaction between time and group variables in the case of attitude and knowledge. A similar interaction was also seen in the deletion of outliers pertaining to attitude competence and test score measurements. However ANOVA results supported that there was an interaction between time and group on participants’ performance, and independent t-test assisted in showing that there was no significant difference between groups at specific testing times of initial testing, and retesting period one. There was significance between differences found in retesting period two. For the analysis of performance with outlier deletion the interaction between time and group remained intact; also independent t-test indicated that there were no significant differences between groups throughout the study. Overall the main interaction effect between time and group only occurred during performance, and there were no interactions for attitude and knowledge. These interactions also remained consistent from analyzing data with and without outliers. This study concludes that performance was the only criteria that experienced any interaction between time and group.

Accomplishments

This research study included multiple accomplishments listed below. 1. The development of a software application to facilitate mixed reality training simulations and application testing. 2. The introduction of new technology to a current CPR curriculum. 3. Survey and performance instrument development and testing. This was an interdisciplinary study that incorporated aspects of engineering, computer science, and health related fields for the purpose of technological advancement and education related
to both CPR and virtual reality training. CPR practices and virtual environments were combined to develop mixed reality training simulations to gauge the impact of using virtual reality as a supplemental tool to reinforce training due to the complexities of varying task that arise from the combination of CPR procedure and out-of-hospital cardiac arrest environments.

The first step to developing a proper environment for mixed reality training simulation included the development and testing of the 3D virtual configurations of the software application. This process used multiple software and coding libraries to gain the sensation of experiencing a 3D mixed reality environment that replicates an out-of-hospital cardiac arrest scenario. Coding libraries that were used are OpenGL and SDL which provided libraries to display geometrical objects. SDL mixer is a subcomponent of SDL that was used to produce event handles and provide sound sources. The coding language for this research was primarily done using C++, which is an object oriented programming language. Other software or libraries that were used in the creation of the CPR training simulation was Blender and FreeVR. Hardware used in this study included a Linux machine, the Viscube C4-SX Multi-Screen Immersive 3D display system, and a fogger machine model FM-1000. All of these components were used to develop this study’s mixed reality simulation with focus on providing a virtual environment with or without the needed distractions to support the out-of-hospital cardiac arrest scenario. Additionally environment testing was completed successfully during the pilot study of this research study that demonstrated that the virtual training was well received, and ready to be fully implemented as a technological component into the CPR training curriculum.
Secondly, this study involved the matter of assessments of both traditional CPR and virtual enhanced CPR training. To properly assess each participant two new instruments were developed to measure participants’ attitudes and performance. The first instrument was a survey which had to undergo validity and reliability checks by CPR professionals, as well as three stages of refinement before being implemented as a measure to detect participants’ attitudes. The survey was composed of one temporary section experience, and four main sections which were self-efficacy components confidence and competence, course attitude, and attitude towards virtual training. Attitude was measured using a 5 point Likert scale ranging from strongly disagree to strongly agree, and experience statements used a yes and no format to evaluate participant’s experience. Each section had been divided into smaller subsections to gain specific measurements throughout the survey. The experience section was composed of statements related to experience and knowledge of each participant. This section was used to gauge the experience of participants to determine if there were any differences in the participant’s range of experience that would exclude them from the research study. Experience observations were conducted for both the control and treatment group in both the pilot and main study. The attitude section of the survey had three main sections. These sections were based on self-efficacy, attitude towards the course, and attitude towards virtual training. The self-efficacy component was further divided into subsections that measured confidence and competence. Attitude towards the course and attitude towards virtual training provided attitude measurements on environment influence, course duration, and self-performance. All statements in the survey were
categorized into areas such as knowledge, self-performance, environmental influence, duration, willingness and motivation.

The other instrument was an adult performance check list that was used to measure each participant’s performance during the adult CPR procedure. The adult performance check list did required reliability testing, even though it was merely an expanded and more detailed form derived from the original course’s AHA approved performance checklist. The Adult performance checklist used in this study was tested using interrater reliability. Performance checks were performed by a single instructor to have consistency within the ratings of participant performance throughout the study. The instructor that participated in this study performance checks were compared to two other expert instructors to determine the reliability of the performance checklist instrument. Performance assessments were conducted during the instructor’s routine CPR training courses using 30 participants equally divided into two courses prior to the pilot study. Each instructor rated the same participant’s performance, and reliability analysis determined using Cronbach’s Alpha and IBM SPSS statistical software in each course. The decision to use at least two courses and two instructors was due to the history of instructor variability which is discussed in the literature of this dissertation. To ensure that there was little variability as possible between performance instrument’s ratings, interrater reliability was measured in both cases. The Adult CPR performance check list was a reliable instrument for checking the performance of participants in this study.

**Broadening the Field of Research for CPR and Virtual Reality Training.**

After the development and testing of tools used in this research study data was then collected and analyzed to determine the contributions made to both the areas of CPR and
engineering. The significance of this proposed study was its contribution to both CPR and virtual reality areas. It provided a new innovative training approach for CPR candidates, as well as providing more information on the effects and use of virtual reality as an educational training tool. Additionally recent changes in the CPR guidelines by the AHA were also measured to assess the trainee’s adaptation to the new 2010 resuscitation guidelines in a simulated out-of-hospital environment.

Enhancing virtual reality is considered among the grand challenges in engineering by the National Academy of Engineering (Diamax, 2012). There are many possibilities that the use of virtual reality can benefit multiple areas, but there is still a need to understand the use of virtual reality and its effects. For instance, what level of fidelity is need as well as how to simulate reality effectively to gain a real response from users? Additionally there is a need to understand how users feel towards using virtual reality in place of traditional approaches? In this study virtual reality was used in a mixed reality out-of-hospital cardiac arrest emergency to attempt to add further explanation to the possible effects and benefits of virtual reality. Although effects in this study were not all significant, they did provide some explanation and understanding to the benefits of virtual reality within the area of CPR. It promoted the technological advancement of CPR by combining the traditional CPR procedure with a newly engineered mixed reality simulation; which provided a new method of training that was not presently within the current School of Nursing or CPR curriculum.

Primary benefits seen from the use of virtual enhancements were noticed in all measurement criteria of this study. The treatment group that experienced virtually enhanced training within the virtual environment had higher attitude means in all areas
including confidence, competence, and course attitude. The virtual training environment was well received from evaluation pertaining attitude towards virtual training. Traditionally taught participants’ attitude diverged negatively away from the positive and increasing attitude of the virtually enhanced trained participants; showed a significant difference among the treatment group demonstrating a significantly higher view towards course attitude. There was a degree of retention of knowledge among the treatment group demonstrating no significant decreases between each testing period. Further testing in the area is needed to directly conclude the effects of virtual reality on knowledge.

The influence of the mixed reality simulation on CPR performance was seen both by an increase in the performance score mean and through observations. During virtual enhancement training the treatment group did score higher than the control group, but the results indicated no statistical significance among group means for retesting period one. A noticeable influence of virtual reality on performance was made during the mixed reality simulations observations. Video recordings showed that participants performed task faster, looked around the scene for additional dangers, spoke to the mannequin, and generally were more excited when compared to the traditional classroom training. These reactions to the virtual training shows promise for its use in the technological advancement of CPR by increasing attitudes and performance, as well as providing additional information on the effects on participants’ reactions and attitudes to the exposure. This study has provided additional information to broaden the areas of both CPR and engineering. It also demonstrates their possible uses as a combination to
improve an area of training that has a long history of declining attitude, knowledge, and performance
Chapter 6

Conclusion

This research study included multiple accomplishments. Accomplishments included the following: the development of a software application to facilitate mixed reality training simulations and application testing, the introduction of new technology to a current CPR curriculum, and survey and performance instrument development and testing. This was an interdisciplinary study that incorporated aspects of engineering, computer science, and health related fields for the purpose of technological advancement and education related to both CPR and virtual reality training. CPR practices and virtual environments were combined to develop mixed reality training simulations to gauge the impact of using virtual reality as a supplemental tool to reinforce training due to the complexities of varying task that arise from the combination of CPR procedure and out-of-hospital cardiac arrest environments.

After the development and testing of tools used in this research study data was then collected and analyzed to determine the contributions made to both the areas of CPR and engineering. The significance of this proposed study was its contribution to both CPR and virtual reality areas. It provided a new innovative training approach for CPR candidates, as well as providing more information on the effects and use of virtual reality as an educational training tool. Additionally recent changes in the CPR guidelines by the
AHA were also measured to assess the trainee’s adaptation to the new 2010 resuscitation guidelines in a simulated out-of-hospital environment.

This study examined the use of training CPR techniques and the uses of virtual reality. It provided a new innovative training approach for CPR candidates, as well as providing more information on the effects and use of virtual reality as an educational training tool. Additionally recent changes in the CPR guidelines by the AHA were also measured to assess the trainee’s adaptation to the new 2010 resuscitation guidelines in a simulated out-of-hospital environment. These assessments were used to answer the primary research questions of this study which are: 1) How does the use of virtual reality environments for CPR training effect knowledge retention compared to traditional methods? 2) How does the use of virtual reality environments for CPR training effect performance compared to traditional training? 3) What are the trainees’ attitudes towards virtual training compared to the traditional classroom training? 4) What effect does time have on the retention of CPR participants between the control and treatment groups?

This study concluded that the treatment group’s virtual enhance training showed some degree of knowledge retention during the intervention (retesting period one), as well as having no significant decreases in knowledge from initial testing to retesting period one and from retesting period one to retesting period two. The control group knowledge results indicated a significant decrease from the initial testing period to retesting period one, and a non-significant decrease from retesting period one to retesting period two. Although the treatment did not experience a significant decrease in knowledge from testing to retesting periods both control and treatment group experienced significant decreases in knowledge from initial testing to the final retesting. There is
also need to further investigate ways to implement knowledge into simulations to provide a greater emphasis on knowledge and performance, as well as attempting to improve knowledge retention by having a higher degree of association between knowledge and performance during simulations.

Performance measurements indicated that the control group outperformed the treatment group non-significantly during initial testing and significantly during retesting period two. Performance was also the only measured criteria that showed a significant interaction between time and group. During the intervention of retesting period one the treatment group increased its performance to outperform the control group, but the numerical statistical difference between group performances were not significant. However, there was an observed effect in participants’ reactions and performance during the video analysis during the treatment group’s intervention. Therefore the influence of the virtual enhancement training cannot be ignored although there was no numerical statistical difference between the control and treatment groups during retesting period one. The influence on performance may have been related to instructor feedback immediately after each performance testing, and moderate stress during the intervention may have reduced the treatment group’s ability to retain information. Also a lower mean measurement for the control group during the retesting one period implied that they received more corrections and feedback for their performance from the instructor, which could increase their final performance; therefore the instructor’s feedback may have had some influence on participants’ performance. Additionally, the influence of having and not having distractions during the mixed reality simulations for the pilot and main studies, the pilot’s treatment groups showed an increase in final performance when
practicing in a calm mixed reality environment after returning to a similarly calm traditional classroom environment. Alternatively, the use of distractions with virtually enhanced training within the main study showed a decrease in performance after participants demonstrated their CPR procedure in a calm environment with previously experiencing a more dramatic training simulation. This also promotes the need for further investigation of the influence of virtually enhanced training when in combination with relevant environment distractions to determine the full impact of mixed reality simulations. There also could have been a decrease participants’ reaction in regards to performance for the treatment group due to the de-escalation of the task at hand, surroundings, and experience that could have resulted in lower performance.

The analysis of group attitude concluded that overall the treatment group’s participants displayed better attitudes by providing higher means over time that were non-significant, but could have the possibility of becoming significant as time progressed. Course attitude displayed significance in favor of the treatment group. The treatment group experienced a positive growth in attitude over time in course attitude, and the control group showed a negative declining trend over the duration of the study. Both groups’ attitude diverged from the point of initial testing to retesting period two.

Overall the main interaction effect between time and group only occurred during performance, and there were no interactions for attitude and knowledge. Also the analysis performed after the removal of outlier date points for attitude competence, performance, and knowledge demonstrated the same results concerning interactions of time and group. Although it is a very controversial topic of keeping or removing outliers, this study showed data analysis in both forms of analysis with the removal outliers.
Removal of outliers showed noticeable changes profiles of the resulting analysis for competence, performance, and knowledge, and considering the variable history of CPR outliers can place a significant influence on results.

**Future Research**

This research study added to the knowledge and technology advancement of CPR as well as providing further research on the uses of the virtual reality as an educational tool. It introduced a new type of mixed reality CPR emergency scenario training for pre-nursing students that was not present within their training curriculum. This research study accomplished its goals of identifying the influence that virtual reality using a mixed reality simulation for CPR training within a short time frame. There is a need for more investigations of the effects of virtual reality usage to be conducted to identify the possible significant effects in knowledge, attitude, and performance over a longer period of time.

One approach that could be used in later studies include retaining participants over a longer period of time, and using repeated mixed reality training simulations with integrated virtual reality experiences to determine the long term influence. Being able to retain participants for six months to a year and comparing the effects of repeated virtually enhanced training would provide a better overview of how virtual training compares to traditional training methods. This approach could also assist in identifying possible retesting intervals as a solution with using mixed reality simulations within a specific time frame to promote CPR retention in performance with little to no instructor involvement. The idea behind this concept would be to develop a mixed reality experience that would boost participants’ ability to retain knowledge, performance, and...
positive attitudes with little decline for at least six months to a year. It would only require the instructors to be present during the two year certification renewals, and require little effort during one to three retesting periods between those certifications. It also could help to reinforce preparedness among fields that require CPR intervention to save lives.

Another approach would be to introduce different virtual environments and emergency situations. Testing environment would include a baseline measurement of traditional CPR testing for four groups. The four groups would be divided among the control group, treatment group #1, treatment group #2, and treatment group #3. Each group would be tested and retested based on testing intervals identified prior to implementation of the training. Similar to this study the control group would only receive classroom environment retesting periods, while the treatment groups #1, #2, and #3 would experience different variations in mixed reality training over a specified timeline. Treatment group #1 would experience a calm mixed reality scenario with minor visuals and auditory distractions. Treatment group #2 would experience a mixed reality scenario with moderate visuals and auditory distractions. Treatment group #3 would experience a mixed reality scenario with multiple major visuals and auditory distractions. Treatment groups would experience the same scenario each retesting period to determine if same scenarios containing the same visual and auditory stimulations will continue to have an effect on participants. This approach would assist in identifying how distractions levels compare between groups and their impact on participants knowledge, performance, and attitude towards CPR and virtual enhancement training.
As another alternative future aspirations could assist in identifying a possible mixed reality training simulation curriculum to be integrated into training curriculums to maximize participant performance and retention. This study would take groups of participants and place them through traditional classroom training to obtain baseline measurements for each group. Each group would then be allowed to go through mixed reality simulations with escalating distractions from three different scenarios. This study would assist in identifying the mixed reality simulations combinations that had the most impact on participants. These simulations could also be integrated into training curriculums to improve participants’ performance as well as integrating a new technological approach to improving training.

Prior to the three previously mentioned training studies being implemented issues with hardware would be addressed. To increase the realism of the environment scenarios, it would be great to not only include single training approaches or procedures, but to also include team based training approaches. Currently the use of the Viscube system can be easily acclimated to develop mixed reality simulations to included additional support for the child and infant CPR procedure. To include team based training the issue of tracking would have to be resolved to allow for the tracking of multiple participants. The current tracking system could be upgraded or expanded to include the ability to track multiple persons and deliver the same level of quality as if there was only one person being tracked. Other hardware changes that would be addressed would be including a high-fidelity full bodied mannequin with integrated audio responses and feedback sensors. These would improve the current human and computer
interaction component of this study. It would allow for induced situations due to verbal auditory responses from the victim, and monitoring of compressions rates.

Due to the future work containing many details it would be a great idea to incorporate both qualitative and quantitative analysis within the study. Qualitative analysis would give an understanding to the reasoning of why participants responded in a specific manner. It would also provide the ability to have participants answer open ended questions and conduct individual interviews. That type of analysis would provide a deeper insight into each participant’s way of thinking and how they felt that the mixed reality simulations affected them. On the other hand the quantitative analysis would allow for specific measurements of criteria, and are better for detecting statistical differences among participants or groups.

The addition of components to address the knowledge and performance barriers of simulations and influences also must be considered in the development of future training applications. Typically during many simulations with a focus on performance there is minor reflection on knowledge during performance especially in the case of CPR. Therefore there is a need to further investigate ways to implement knowledge into simulations to provide a greater emphasis on knowledge and performance, as well as attempting to improve knowledge retention by having a higher degree of association between knowledge and performance during simulations. There could be an introduction of stages that take place within the simulation which place barriers between the victim and the responder, and participants would have to respond to those barriers (knowledge barriers) as a precursor to being able to perform the performance duty required for the simulation. Knowledge barriers can take many forms that are relevant enough to the
simulation to not reduce the participant’s level of immersion. This design would be essential in assisting participants in combing both knowledge and performance during simulation practices, and in the case of CPR it could possibly provide a higher or possibly positive degree of knowledge retention.

There is also a need to reduce instructor influence on participants during simulation studies. Future aspects of this CPR and mixed reality simulation study would eliminate instructor influence entirely after gaining baseline measurements during the initial testing of participants. Within this study the instructor provided feedback after each performance testing, which could have assisted the control group during the last retesting. Eliminating the instructor’s influence would allow for data to be collected that is solely based on that individual participant performance, thus providing a more accurate account of the influences of the simulation when compared to traditional training methods. This method would also reduce the influence of confounding variables within the study as well.

Additionally the combination of these future work research studies would facilitate a long term study that would provide very detailed information on the influence of mixed reality training simulations for CPR training. By using the first study to identify an ideal point for retesting periods and repeated measures using virtually enhanced training it can be used to determine retesting periods for the study that would have escalating distractions. That study can then be used to identify which combinations of emergency scenarios to use to maximize participants performance from integrating the mixed reality training simulations into a CPR training curriculum. The combination of all three future studies with qualitative and quantitative analysis would provide a better
understanding of the impact of using virtual reality to enhance training and its long term effects.

Limitations

Although the uses of many different libraries and software assisted in developing the virtual scenario for CPR training there are limitations that have to be addressed due to hardware. One limitation is the Viscube’s tracking capabilities. Due to its inability to track multi persons in this design it was only allowed for focused CPR training enhancement on solo training aspects. In traditional training not only was solo training performed but also team training up to three individuals was completed. This is not to say that team training inside the Viscube is not possible. Simply adding another individual into the training scenario with a pair of Infitec glasses would suffice, but the tracking system would only track the individual holding the tracking equipment. Displaying geometry also had to be taken into consideration which varies with the tracking system as well. This process can be adjusted by implementing different code into the tracking system to allow it to detect two or more devices, but there will be a computational expense associated with the additional tracking. Also there would be the issue of suitable space, which could be adjusted by acquiring a larger system with greater dimensions to comfortably fit multiple users. These two additions would allow team based CPR training to take place as opposed to one person training.

Another additional limitation of this study was due to segmentation faults, and the freezing of the viscube system. It is important to state that systems test conducted during the study did not experience any segmentation faults or freezing of the system during the pilot testing study. As the timeline approached the main study, system upgrades were
conducted by a technical team that was out of the study’s control, in addition to power outages occurring within the lab that contain the mixed reality CPR simulation hardware (viscube). Fortunately during the study no power outages were experienced, and one segmentation fault did not affect the performance of one participant due to the instant restarting of the system. One freezing of the system incident occurred, but also did not affect the one participant’s performance, due to the system correcting itself within a timely manner.

Some CPR limitations would refer to the use of different mannequin models, and instructor feedback, and knowledge emphasis. Due to the type of model that was used in the traditional CPR courses; monitoring performance was limited to visual observations of CPR performance based on the American Heart Association’s 2010 Guidelines. The mannequin was preprogrammed to meet those specifications. There was no way to induce different biological complications such as sporadic inconsistent breathing, or to have the mannequin vocalize the experience of pain. This problem does not limit the study based on traditional CPR versus enhanced virtual training comparison, but the use of a higher quality mannequin such as those used in hospital mega code training may provide more detailed data to further understand out-of-hospital cardiac arrest situations. Simply stated it may serve the purpose of improving the realism of the virtual environment scenario training. On the other hand there would be a significant increase in cost. Although more costly mannequins may render more detailed data; it is important to note that the currently used mannequins for traditional CPR provided adequate feedback to allow for the collection of the required data needed for this research. Additionally
there is always the issue of fidelity for any simulation, and a more experienced individual may require a higher level of fidelity to completely immerse them into the simulation.

Another typical issue for CPR trainees involves instructor feedback which can vary from instructor to instructor. In this study instructor feedback during retesting period could have been absorbed more by the control group when compared to the treatment group due to the intervention. Since feedback was given immediately after performing adult CPR, participants that experienced the intervention may have had difficulty retaining the information due to the previous moderate stress conditions. This could have had an impacted on participants performance evaluations, resulting in a less stressed participant being able to absorb or retain more information better than a participant that has been in a stressful situation. Due to this study being performed on a life-saving process, it would be unethical to not allow the instructor to provided corrections after performance for participants who did not perform adequately.

Finally there is the emphasis placed on knowledge during simulations that generally have a greater ability to detect performance. Typically during many simulations with a focus on performance there is minor reflection on knowledge during performance especially in the case of CPR. Similarly this study had both knowledge and performance measurements, but within simulations there was some reflection on knowledge that pertained to the task at hand only. The knowledge data collect was efficient enough to draw conclusions for this study, but future studies may need to place more emphasis on both knowledge and use performance as a medium to assist in knowledge retention by providing memorable experiences involving both.
Other limitations within this study would refer to the sample size, although multiple testing periods assisted with that issue, and samples were the size of a typical CPR class at the university. The sample was not actually being generated from a random pool of participants due to the studies university classroom setting. The sample data targeted only pre-nursing participants and not distinguish between or test all professions within the school of nursing with more experience that may be required to take or retake CPR. Longer study duration would help to validate this study’s results even more as well as a study with participants only experiencing virtual/mixed reality training would assist in showing further influence of using virtual reality.
REFERENCES


Kaphingst, K., Persky, S., McCall, C., Lachance, C., Loewenstein, J., Beall, A., & Blascovich, J. (2009). Testing the effects of educational strategies on


# Final CPR Survey

## Experience

This section is intended to measure experience or knowledge of each participant during training and rated Yes or No.

Instructions: Please read the statements below and fill in the circle that best indicates your answer.

1. I have personally experienced performing CPR.
   - [ ] Yes
   - [x] No

2. I have previously attended a CPR training course.
   - [x] Yes
   - [ ] No

3. My last CPR course was before the new 2010 guidelines were introduced.
   - [x] Yes
   - [ ] No

4. I have performed CPR in a hospital emergency.
   - [ ] Yes
   - [x] No

*5. I have performed CPR in an out-of-hospital emergency.
   - [ ] Yes
   - [x] No

*6. I have had continuous chest compression CPR training
   - [ ] Yes
   - [x] No
Final CPR Survey

Attitude

This section is intended to measure attitude with a focus on self-performance and self-efficacy (belief in one’s own ability and knowledge).

Instructions: Please read the statements below and fill in the circle that best indicates your answer.

* 7. I hesitate to attempt CPR because I do not know how to resuscitate well.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

* 8. I feel confident that I could perform CPR in a real emergency.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

* 9. I would probably do more harm than good if I tried to perform CPR in a real emergency.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

* 10. I feel confident in performing CPR.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 11. I am able to work as a member of a resuscitation (CPR) team.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 12. I am able to work as a leader of a resuscitation (CPR) team.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 13. I hesitate to perform defibrillation, because I am not ready.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 14. I think that I need more BLS training to correctly perform CPR.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 15. I am knowledgeable about the current CPR process and guidelines.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 16. I can recognize cardiac arrest.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

* 17. I have the skills to effectively perform CPR.
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. I am able to perform defibrillation with an AED.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>19. I am aware of current CPR guidelines.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>20. I am aware of the effectiveness of bystander CPR.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>21. I understand the uses of Continuous Chest Compressions CPR.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>22. I understand the current resuscitation guidelines.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>23. I am aware of dangers in my environment before initiating CPR.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>24. I will perform CPR in a dangerous environment.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>25. My last CPR course was too short</td>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>
### Final CPR Survey

#### Attitude Towards the Course

This section is intended to measure attitude towards the course.

Instructions: Please read the statements below and fill in the circle that best indicates your answer.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>26. This CPR course was too long</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>27. I enjoyed the CPR course.</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>28. I feel more prepared after taking this CPR course.</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>29. New resuscitation guidelines are difficult to perform during an emergency.</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>30. Resuscitation guidelines simplify CPR medical practice.</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>31. I am motivated to attend further courses.</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>32. This course has improved my readiness to perform CPR better than previous courses.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>33. The environment helped to improve my CPR performance.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>34. Distractions in the environment affected my CPR performance.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Final CPR Survey

### Virtual CPR Training

This section is intended to measure attitude towards virtual training.

Instructions: Please read the statements below and fill in the circle that best indicates your answer.

*35. Virtual hazards or distractions affected my CPR performance (i.e. smoke, sounds, etc.).
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*36. I felt distracted by sounds while performing CPR in the virtual environment.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*37. I felt distracted by visible hazards during virtual training.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*38. Sounds or other effects made me nervous or anxious while performing CPR.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*39. I think that virtual training is more realistic than traditional classroom training.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*40. I feel more prepared for an out-of-hospital cardiac arrest emergency when using virtual training.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree

*41. I would prefer that all CPR performance skills were done in a virtual environment setting.
   - [ ] Strongly Disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly Agree
# Adult CPR – Performance Checklist

Student’s name_______________________________  Date_______  Score_______

Please use an X or check mark to indicate the completion of a task in the Points Earned section. Provide any additional comments that reflect the student’s performance.

<table>
<thead>
<tr>
<th>#</th>
<th>Area of Assessment</th>
<th>Area Subcategories Assessment</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey the scene (4 pts)</td>
<td>Check for danger (4 pts)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check for consciousness (3 pts)</td>
<td>Check for consciousness (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tap and shout (2 pts)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Call 911 (3 pts)</td>
<td>Unresponsive: call 911 or designate someone to call 911 (3 pts)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Check carotid pulse (3 pts)</td>
<td>Correct Hand placement (2 pts)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check for 5 to 10 seconds (1 pt)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Compressions (6 pts)</td>
<td>Correct hand/finger location on the sternum (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Responder’s shoulders are positioned to deliver vertical force (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elbows remain straight and locked (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Responder bends at the hip during compressions (1 pt)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Correct 2 inch compression depth (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Correct Rhythm with chest recoil (1 pt)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Delivers compressions (3 pts)</td>
<td>30 compressions in 18 seconds (5 pts)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rescue Breaths (5 pts)</td>
<td>Correctly open airway (i.e. Head tilt – chin lift) (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gives 2 rescue breaths (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Correct length of breathe (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seal Nose before giving breaths (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sufficient chest rise (1 pt)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Compressions (6 pts)</td>
<td>Correct hand/finger location on the sternum (1 pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Responder’s shoulders are positioned to deliver vertical force (1 pt)</td>
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<td></td>
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</tr>
</tbody>
</table>
|   | Correct 2 inch compression depth (1 pt)
|   | Correct Rhythm with chest recoil (1 pt)
| 9 | Rescue Breaths (5 pts) |
|   | Correctly open airway (i.e. Head tilt – chin lift) (1 pt) |
|   | Gives 2 rescue breaths (1 pt) |
|   | Correct length of breathe (1 pt) |
|   | Seal Nose before giving breaths (1 pt) |
|   | Sufficient chest rise (1 pt) |
| 10 | Compression to Breathe Ratio (6 pts) |
|   | Compression to breathe ratio 30:2 per cycle (6 pts) |
| 11 | Number of cycles completed within 2 minutes (4 pts) |
|   | 1 to 2 cycles (1 pt) |
|   | 3 to 4 cycles (2 pts) |
|   | 5 cycles (4 pts) |
| Total Points |   |
| Comments |   |
American Heart Association

Basic Life Support for Healthcare Providers

Written Examination

Version A

March 2011

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BLS for Healthcare Providers Course
Version A

Please do not mark on this examination. Record the best answer on the separate answer sheet.

1. The rescuer knows the rescue breath for an infant victim is effective when
   A. the stomach rises visibly.
   B. the chest rises visibly.
   C. the child ventilation bag is completely compressed.
   D. the rescuer can hear an air leak around the mask.

2. When a child has a heart rate greater than 60 per minute and a pulse but is not breathing effectively, the rescuer should
   A. give breaths and chest compressions.
   B. give breaths without chest compressions.
   C. give chest compressions without breaths.
   D. connect the AED to the child and analyze.

3. Which of the following ventilation devices/techniques is not recommended for a single rescuer to provide breaths during CPR?
   A. Bag-mask device
   B. Mouth-to-barrier device technique
   C. Mouth-to-mouth technique
   D. Mouth-to-mask technique

4. Which of the following options lists the correct compression and ventilation rates for 2-rescuer CPR in the presence of an advanced airway?
   A. Compress at a rate of at least 100 per minute, 1 breath every 8 to 10 seconds.
   B. Compress at a rate of at least 60 per minute, 1 breath every 6 to 8 seconds.
   C. Compress at a rate of at least 100 per minute, 2 breaths every 5 to 10 seconds.
   D. Compress at a rate of at least 60 per minute, 1 breath every 5 to 10 seconds.

5. After the AED delivers a shock, the rescuer should
   A. wait for the AED to reanalyze the rhythm.
   B. immediately restart CPR, beginning with chest compressions.
   C. provide 2 ventilations to the victim.
   D. immediately check the carotid pulse for no more than 10 seconds.
8. If an unresponsive infant is not breathing and has a heart rate of 53 beats per minute and signs of poor perfusion despite oxygenation and ventilation with a bag and mask, which of the following should you perform?

A. One rescue breath every 10 seconds
B. Cyclos of back blows and chest thrusts
C. Chest compressions without breaths
D. Both chest compressions and breaths

7. Where should the hands be placed to perform chest compressions on an adult?

A. On the lower half of the breastbone
B. In the center of the breastbone
C. On the upper portion of the abdomen
D. In the upper half of the breastbone

8. The 2 thumb-encircling hands technique for the infant

A. produces less blood flow than the 2-finger technique.
B. is the preferred chest compression technique for 2-rescuer CPR.
C. is the preferred chest compression technique for 1-rescuer CPR.
D. generates less blood pressure than the 2-finger technique.

9. The recommended rate for performing chest compressions for victims of all ages is

A. at least 40 compressions per minute.
B. at least 60 compressions per minute.
C. at least 80 compressions per minute.
D. at least 100 compressions per minute.

10. The depth of chest compressions for an adult victim should be at least

A. 1 inch (2.5 cm).
B. 2 inches (5 cm).
C. 3 inches (7.5 cm).
D. 4 inches (10 cm).

11. The compression-to-breaths ratio for 2-rescuer child CPR is

A. 30:2.
B. 5:1.
C. 20:2.
D. 15:2.
12. The compression-to-ventilation ratio for 1-rescuer adult CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

13. The compression-to-ventilation ratio for 2-rescuer infant CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

14. The recommended depth of chest compressions for an infant is
   A. at least one fourth the depth of the chest, approximately 1 inch (2.5 cm).
   B. at least one third the depth of the chest, approximately 1.5 inches (4 cm).
   C. at least one half the depth of the chest, approximately 2 inches (5 cm).
   D. at least two thirds the depth of the chest, approximately 3 inches (8 cm).

15. Which of the following victims needs CPR?
   A. A victim with a pulse who is having trouble breathing
   B. A victim with chest pain and indigestion
   C. A victim who is unresponsive with no normal breathing and no pulse
   D. A victim who is unresponsive but is breathing adequately

16. Why is it important to compress to the appropriate depth during CPR?
   A. Adequate depth of compression is needed to create blood flow during compressions.
   B. Adequate depth of compression is needed to create air flow into the lungs and adequate oxygenation.
   C. Adequate depth of compression is needed to prolong asystole.
   D. Adequate depth of compression is needed to stimulate spontaneous respirations.

17. As soon as an AED becomes available, which of the following is the first step the rescuer should perform to operate the AED?
   A. Place the AED pads on the chest.
   B. Deliver 2 rescue breaths before using the AED.
   C. Turn on the AED.
   D. Complete 5 cycles of chest compressions.
18. If a victim of foreign body airway obstruction becomes unresponsive, the rescuer should send someone to activate the emergency response system and immediately

A. performs abdominal thrusts
B. performs blind finger sweeps
C. start CPR beginning with compressions
D. calls the victim's doctor

19. When should the rescuer initially ensure that the scene is safe?

A. When the rescuer first sees a potential victim
B. After the rescuer activates the emergency response system
C. As emergency medical services arrive on the scene
D. After an AED attached to the victim delivers a shock

20. The 2010 AHA Guidelines for CPR and ECC recommend that to identify cardiac arrest in an unresponsive victim with no breathing (or no normal breathing), a healthcare provider should check a pulse for no more than

A. 25 seconds.
B. 10 seconds.
C. 15 seconds.
D. 20 seconds.

21. During bag-mask ventilation, which of the following is recommended to minimize the risk of gastric inflation?

A. Give breaths as quickly as you can.
B. Give each breath over as long a time as you can (several seconds).
C. Give the largest breaths that you can.
D. Give a breath just until you see the chest rise.

22. After you identify an unresponsive victim with no breathing (or no normal breathing) and no pulse, chest compressions should be initiated within

A. 25 seconds.
B. 10 seconds.
C. 30 seconds.
D. 60 seconds.

23. In 2-rescuer CPR, while the first rescuer begins chest compressions, the second rescuer should

A. count compressions aloud.
B. check for a pulse during compressions.
C. do nothing until the first rescuer needs relief.
D. maintain an open airway and give ventilations.
24. After the airway is opened, which of the following correctly states the proper technique for delivering mouth-to-mouth ventilation?

A. The rescuer opens the airway, seals his or her mouth over the victim's mouth, pinches the victim's nose closed, and gives 2 breaths while watching for the chest to rise.
B. The rescuer opens the airway, puts his or her mouth on the victim's mouth, and gives several small puffs while trying to avoid making the chest rise.
C. The rescuer opens the airway, seals his or her mouth on the victim's mouth, and gives 1 slow breath for a duration of 5 seconds.
D. The rescuer opens the airway, puts his or her mouth on the victim's mouth, and gives 5 slow breaths, each with a duration of 2 seconds, while watching for the chest to rise.

25. When administering breaths by using a bag-mask device for a child who is not breathing but does have a pulse, the rescuer should

A. squeeze the bag as often as possible.
B. give breaths at the rate of 1 breath every 3 to 5 seconds.
C. position the child on his or her stomach.
D. avoid performing a head tilt.
American Heart Association

Basic Life Support for Healthcare Providers

Written Examination

Version B

March 2011

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BLS for Healthcare Providers Course
Version B

Please do not mark on this examination. Record the best answer on the separate answer sheet.

1. After the airway is opened, which of the following correctly states the proper technique for delivering mouth-to-mouth ventilation?
   A. The rescuer opens the airway, seals his or her mouth over the victim's mouth, pinches the victim's nose closed, and gives 2 breaths while watching for the chest to rise.
   B. The rescuer opens the airway, puts his or her mouth on the victim's mouth, and gives several small puffs while trying to avoid making the chest rise.
   C. The rescuer opens the airway, seals his or her mouth on the victim's mouth, and gives 1 slow breath for a duration of 5 seconds.
   D. The rescuer opens the airway, puts his or her mouth on the victim's mouth, and gives 5 slow breaths, each with a duration of 2 seconds, while watching for the chest to rise.

2. High-quality CPR includes starting compressions within how many seconds after recognition of cardiac arrest in adults?
   A. 10
   B. 15
   C. 20
   D. 30

3. When administering breaths by using a bag-mask device for a child who is not breathing but does have a pulse, the rescuer should
   A. squeeze the bag as often as possible
   B. Give breaths at the rate of 1 breath every 3 to 5 seconds.
   C. position the child on his or her stomach.
   D. avoid performing a head tilt.

4. Gastric inflation is more likely to occur if the rescuer
   A. does not make a good seal between the face and the mask.
   B. gives breaths too quickly or with too much force.
   C. gives each breath over 1 second.
   D. gives volume just sufficient to see the chest rise.

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5. Complete chest recoil contributes to CPR success by
   A. reducing the fatigue of the rescuer.
   B. allowing the heart to refill with blood between compressions.
   C. reducing the risk of rib fractures.
   D. increasing the rate of chest compressions.

6. Which of the following is the preferred chest compression technique for 2-rescuers CPR in an infant?
   A. 2 fingers
   B. 2 thumb-encircling hands
   C. 1 hand
   D. Either 1 or 2 hands

7. Which of the following is a characteristic of high-quality CPR in adults?
   A. Minimizing recoil
   B. Compressing at a depth of about 1 inch
   C. Compressing at a depth of at least 2 inches
   D. Checking for a pulse every minute

8. The correct depth of chest compressions for a child is
   A. at least one fourth the depth of the chest, approximately 1.5 inches (4 cm).
   B. at least one third the depth of the chest, approximately 2 inches (5 cm).
   C. at least two thirds the depth of the chest, approximately 4 inches (10 cm).
   D. at least three fourths the depth of the chest, approximately 4.5 inches (12 cm).

9. The compression-to-ventilation ratio for 1-rescuers child CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

10. The compression-to-ventilation ratio for 2-rescuers adult CPR is
    A. 30:2.
    B. 5:1.
    C. 20:2.
    D. 15:2.
11. The compression-to-ventilation ratio for 1-rescuer infant CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

12. The proper compression rate for victims of all ages is at least
   A. 30 compressions per minute.
   B. 50 compressions per minute.
   C. 100 compressions per minute.
   D. 200 compressions per minute.

13. Which of the following victims needs CPR?
   A. A victim with a pulse who is having trouble breathing.
   B. A victim with chest pain and indigestion.
   C. A victim who is unresponsive with no normal breathing and no pulse.
   D. A victim who is unresponsive but is breathing adequately.

14. Ideally, interruptions in chest compressions should be
   A. limited to less than 10 seconds.
   B. performed as often as needed to assess the victim.
   C. longer than 10 seconds.
   D. performed every 6 minutes.

15. The rescuer should deliver a shock with an AED after
   A. the AED advises a shock, charges, and prompts the rescuer to push the shock button.
   B. completion of 2 cycles of compressions and breaths.
   C. placement of an advanced airway.
   D. a check for a carotid pulse.

16. If an AED is used for a child less than 8 years of age,
   A. infant pads may be used if pediatric pads are unavailable.
   B. only adult pads or a dose attenuator may be used.
   C. adult pads/dose may be used if pediatric pads/dose attenuator are not available.
   D. adult pads may be used, but they should be cut in half before application.
17. Why is it important to compress to the appropriate depth during CPR?
   A. Adequate depth of compression is needed to create blood flow during compressions.
   B. Adequate depth of compression is needed to create air flow into the lungs and adequate oxygenation.
   C. Adequate depth of compression is needed to prolong asystole.
   D. Adequate depth of compression is needed to stimulate spontaneous respirations.

18. If a victim of foreign body airway obstruction becomes unresponsive, the rescuer should send someone to activate the emergency response system and immediately
   A. performs abdominal thrusts
   B. performs blind finger sweeps
   C. start CPR beginning with compressions
   D. calls the victim's doctor

19. For which of the following would it be appropriate to move an adult victim who needs CPR?
   A. When help is more than 15 minutes away from the scene
   B. To locate the AED when one is not available
   C. When the adult victim is in a dangerous environment
   D. As soon as the adult is found to be in arrest

20. Where should a rescuer attempt to palpate the brachial pulse in an infant?
   A. On the outside of the lower arm, near the wrist
   B. Inside the upper arm, between the elbow and shoulder
   C. On the radial side of the upper arm, near the groin
   D. On the side of the neck, near the trachea

21. Which of the following is a characteristic of high-quality CPR?
   A. Compressing at a rate of 80 per minute
   B. Minimizing chest recoil
   C. Compressing at a depth of 1 inch
   D. Minimizing interruptions in chest compressions

22. To reduce rescuer fatigue during team CPR, compressor roles should be switched about every
   A. 1 cycle
   B. 3 cycles
   C. 5 cycles
   D. 8 cycles

BLS for Healthcare Providers Exam Version A
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23. Which of the following correctly compares characteristics of chest compressions in adults with those in infants and children?

A. Start compressions: for adults, within 10 seconds; for children/infants, within 30 seconds
B. Chest compression rate: for adults, at least 80 compressions per minute; for children/infants, at least 100 compressions per minute
C. Compression depth: for adults, at least 2 inches; for children/infants, at least one third the depth of the chest
D. Compression-to-ventilation ratio for 2 rescuers: for adults, 30:2; for children/infants, 10:2

24. Which of the following ventilation devices/techniques is not recommended for a single rescuer to provide breaths during CPR?

A. Bag-mask device
B. Mouth-to-barrier device technique
C. Mouth-to-mouth technique
D. Mouth-to-mask technique

25. Which of the following options lists the correct compression and ventilation rates for 2-rescuer CPR in the presence of an advanced airway?

A. Compress at a rate of at least 100 per minute, 1 breath every 6 to 8 seconds.
B. Compress at a rate of at least 60 per minute, 1 breath every 5 to 8 seconds.
C. Compress at a rate of at least 100 per minute, 2 breaths every 5 to 10 seconds.
D. Compress at a rate of at least 60 per minute, 1 breath every 5 to 10 seconds.
American Heart Association

Basic Life Support for Healthcare Providers

Written Examination

Version B

March 2011

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BLS for Healthcare Providers Course
Version B

Please do not mark on this examination. Record the best answer on the separate answer sheet.

1. After the airway is opened, which of the following correctly states the proper technique for delivering mouth-to-mouth ventilation
   A. The rescuer opens the airway, seals his or her mouth over the victim’s mouth, pinches the victim’s nose closed, and gives 2 breaths while watching for the chest to rise.
   B. The rescuer opens the airway, puts his or her mouth on the victim’s mouth, and gives several small puffs while trying to avoid making the chest rise.
   C. The rescuer opens the airway, seals his or her mouth on the victim’s mouth, and gives 1 slow breath for a duration of 5 seconds.
   D. The rescuer opens the airway, puts his or her mouth on the victim’s mouth, and gives 5 slow breaths, each with a duration of 2 seconds, while watching for the chest to rise.

2. High-quality CPR includes starting compressions within how many seconds after recognition of cardiac arrest in adults.
   A. 10
   B. 15
   C. 20
   D. 30

3. When administering breaths by using a bag-mask device for a child who is not breathing but does have a pulse, the rescuer should
   A. Squeeze the bag as often as possible.
   B. Give breaths at the rate of 1 breath every 3 to 5 seconds.
   C. Position the child on his or her stomach.
   D. Avoid performing a head tilt.

4. Gastric inflation is more likely to occur if the rescuer
   A. Does not make a good seal between the face and the mask.
   B. Gives breaths too quickly or with too much force.
   C. Gives each breath over 1 second.
   D. Gives volume just sufficient to see the chest rise.

BLS for Healthcare Providers Exam Version B
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5. Complete chest recoil contributes to CPR success by
   A. Reducing the fatigue of the rescuer.
   B. Allowing the heart to refill with blood between compressions.
   C. Reducing the risk of rib fractures.
   D. Increasing the rate of chest compressions.

6. The rescuer knows the rescue breath for an infant victim is effective when
   A. The stomach rises visibly.
   B. The chest rises visibly.
   C. The child ventilation bag is completely compressed.
   D. The rescuer can hear an air leak around the mask.

7. When a child has a heart rate greater than 60 per minute and a pulse but is not
   breathing effectively, the rescuer should
   A. Give breaths and chest compressions
   B. Give breaths without chest compressions.
   C. Give chest compressions without breaths.
   D. Connect the AED to the child and analyze.

8. Which of the following ventilation devices/techniques is not recommended for a single
   rescuer to provide breaths during CPR?
   A. Bag-mask device
   B. Mouth-to-barrier device technique
   C. Mouth-to-mouth technique
   D. Mouth-to-mask technique

9. Which of the following options lists the correct compression and ventilation rates for
   2-rescuer CPR in the presence of an advanced airway?
   A. Compress at a rate of at least 100 per minute, 1 breath every 6 to 8 seconds.
   B. Compress at a rate of at least 60 per minute, 1 breath every 6 to 8 seconds.
   C. Compress at a rate of at least 100 per minute, 2 breaths every 5 to 10 seconds.
   D. Compress at a rate of at least 60 per minute, 1 breath every 5 to 10 seconds.

10. After the AED delivers a shock, the rescuer should
    A. Wait for the AED to reanalyze the rhythm.
    B. Immediately restart CPR, beginning with chest compressions.
    C. Provide 2 ventilations to the victim.
    D. Immediately check the carotid pulse for no more than 10 seconds.
11. If an unresponsive infant is not breathing and has a heart rate of 53 beats per minute and signs of poor perfusion despite oxygenation and ventilation with a bag and mask, which of the following should you perform?

A. One rescue breath every 10 seconds  
B. Cycles of back blows and chest thrust  
C. Chest compressions without breaths  
D. Both chest compression and breaths  

12. Where should the hands be placed to perform chest compressions on an adult?

A. On the lower half of the breastbone  
B. In the center of the breastbone  
C. On the upper portion of the abdomen  
D. In the upper half of the breastbone  

13. The 2 thumb-encircling hands technique for the infant

A. Produces less blood flow than the 2-finger technique.  
B. Is the preferred chest compression technique for 2-rescuer CPR.  
C. Is the preferred chest compression technique for 1-rescuer CPR.  
D. Generates less blood pressure than the 2-finger technique.  

14. The recommended rate for performing chest compressions for victims of all ages is

A. At least 40 compressions per minute  
B. At least 60 compressions per minute  
C. At least 80 compressions per minute  
D. At least 100 compressions per minute  

15. The depth of chest compressions for an adult victim should be at least

A. 1 inch (2.5 cm).  
B. 2 inches (5 cm).  
C. 3 inches (7.5 cm).  
D. 4 inches (10 cm).  

16. The compression-to-breaths ratio is 2-rescuers child CPR is

A. 30:2.  
B. 5:1.  
C. 20:2.  
D. 15:2.
17. The compression-to-ventilation ratio for 1-rescuer adult CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

18. The compression-to-ventilation ratio for 2-rescuer infant CPR is
   A. 30:2.
   B. 5:1.
   C. 20:2.
   D. 15:2.

19. The recommended depth of chest compressions for an infant is
   A. At least one fourth the depth of the chest, approximately 1 inch (2.5 cm).
   B. At least one third the depth of the chest, approximately 1.5 inches (4 cm).
   C. At least one half the depth of the chest, approximately 2 inches (5 cm).
   D. At least two thirds the depth of the chest, approximately 3 inches (8 cm).

20. Which of the following victims needs CPR?
   A. A victim with a pulse who is having trouble breathing
   B. A victim with chest pain and indigestion
   C. A victim who is unresponsive with no normal breathing and no pulse
   D. A victim who is unresponsive but is breathing adequately

21. Why is it important to compress to the appropriate depth during CPR?
   A. Adequate depth of compression is needed to create blood flow during compressions.
   B. Adequate depth of compression is needed to create air flow into the lungs and adequate oxygenation.
   C. Adequate depth of compression is needed to prolong asystole.
   D. Adequate depth of compression is needed to stimulate spontaneous respirations.

22. As soon as an AED becomes available, which of the following is the first step the rescuer should perform to operate the AED?
   A. Place the AED pads on the chest.
   B. Deliver 2 rescue breaths before using the AED.
   C. Turn on the AED.
   D. Complete 5 cycles of chest compression.

BLS for Healthcare Providers Exam Version B
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23. If a victim of foreign body airway obstruction becomes unresponsive, the rescuer should send someone to activate the emergency response system and immediately

A. Performs abdominal thrust  
B. Performs blind finger sweeps  
C. Start CPR beginning with compressions  
D. Calls the victim’s doctor

24. When should the rescuer initially ensure that the scene is safe?

A. When the rescuer first sees a potential victim  
B. After the rescuer activates the emergency response system  
C. As emergency medical services arrive on the scene  
D. After an AED attached to the victim delivers a shock

25. The 2010 AHA Guidelines for CPR and ECC recommend that to identify cardiac arrest in an unresponsive victim with no breathing (or no normal breathing), a healthcare provider should check a pulse for no more than

A. 25 seconds.  
B. 10 seconds.  
C. 15 seconds.  
D. 20 seconds.

26. During bag-mask ventilation, which of the following is recommended to minimize the risk of gastric inflation?

A. Give breaths as quick as you can.  
B. Give each breath over as long a time as you can (several seconds).  
C. Give the largest breaths that you can.  
D. Give a breath just until you see the chest rise.

27. After you identify an unresponsive victim with no breathing (or no normal breathing) and no pulse, chest compressions should be initiated within

A. 25 seconds.  
B. 10 seconds.  
C. 30 seconds.  
D. 60 seconds.
28. In 2-rescuer CPR, while the first rescuer begins chest compressions, the second rescuer should

A. Count compressions aloud.
B. Check for a pulse during compressions.
C. Do nothing until the first rescuer needs relief.
D. Maintain an open airway and give ventilations.

29. After the airway is opened, which of the following correctly states the proper technique for delivering mouth-to-mouth ventilation?

A. The rescuer opens the airway, seals his or her mouth over the victim’s mouth, pinches the victim’s nose closed, and gives 2 breaths while watching for the chest to rise.
B. The rescuer opens the airway, puts his or her mouth on the victim’s mouth, and gives several small puffs while trying to avoid making the chest rise.
C. The rescuer opens the airway, seals his or her mouth on the victim’s mouth, and gives 1 slow breath for a duration of 5 seconds.
D. The rescuer opens the airway, puts his or her mouth on the victim’s mouth, and gives 5 slow breaths, each with a duration of 2 seconds, while watching for the chest to rise.

30. When administering breaths by using a bag-mask device for a child who is not breathing but does have a pulse, the rescuer should

A. Squeeze the bag as often as possible.
B. Give breaths at the rate of 1 breath every 3 to 5 seconds.
C. Position the child on his or her stomach.
D. Avoid performing a head tilt.
Modified Version C Retesting Two Knowledge Test

Modified version C of the knowledge test followed the same format as Modified version B, except for a change in the first five questions.
BLS for Healthcare Providers Course  
Version C  

Please do not mark on this examination. Record the best answer on the separate answer sheet.

1. Which of the following is the preferred chest compression technique for 2-rescuer CPR in an infant?
   A. 2 fingers  
   B. 2 thumb-encircling hands  
   C. 1 hand  
   D. Either 1 or 2 hands

2. Which of the following is a characteristic of high-quality CPR in adults?
   A. Minimize recoil  
   B. Compressing at a depth of about 1 inch  
   C. Compressing at a depth of at least 2 inches  
   D. Checking for a pulse every minute

3. The correct depth of chest compressions for a child is
   A. At least one fourth the depth of the chest, approximately 1.5 inches (4 cm).  
   B. At least one third the depth of the chest, approximately 2 inches (5 cm).  
   C. At least two thirds the depth of the chest, approximately 4 inches (10 cm).  
   D. At least three fourths the depth of the chest, approximately 4.5 inches (12 cm).  

4. The compression-to-ventilation ratio for 1-rescuer child CPR is
   A. 30:2.  
   B. 5:1.  
   C. 20:2.  
   D. 15:2.

5. The compression-to-ventilation ratio for 2-rescuer adult CPR is
   A. 30:2.  
   B. 5:1.  
   C. 20:2.  
   D. 15:2.

BLS for Healthcare Providers Exam Version C  
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IRB Approval

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on January 24, 2017. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator: GRANVILLE, ALANZO D
Co-Investigator(s): BOLUS, NORMAN E
Protocol Number: X130207004
Protocol Title: Construction of 3D Cardiopulmonary Resuscitation Emergency Scenarios for First Responder Pre-Nursing Training on Stereoscopic Display Systems

The IRB reviewed and approved the above named project on 2/11/13. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.

IRB Approval Date: 2/11/13
Date IRB Approval Issued: 2/11/13

Marilyn Doss, M.A.
Vice Chair of the Institutional Review Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.

470 Administration Building
701 20th Street South
205.934.3789
Fax 205.934.1301
irb@uab.edu

The University of Alabama at Birmingham
Mailing Address:
AB 470
1530 3RD AVE S
BIRMINGHAM, AL 35294-0104
Informed Consent Document

TITLE OF RESEARCH: Construction of 3D Cardiopulmonary Resuscitation Emergency Scenarios for First Responder Pre-Nursing Training on Stereoscopic Display Systems

IRB PROTOCOL: X130207004

INVESTIGATOR: Alanzo D. Granville

SPONSOR: UAB Department of Mechanical Engineering

Explanation of Procedures

You are being asked to participate in a research study that examines experiences in CPR training. This study will measure both the retention and performance of participants during CPR training. Both measurements will be obtained using routine examination and routine performance check lists. Additionally, as part of the research, opinion surveys will be used to record attitudes towards training at the end of each session.

The purpose of this research study is to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. This research study will measure retention, performance, and attitude of pre-nursing students enrolled in American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course. This study will allow for a better interpretation of how the virtual environments can be used to reinforce student CPR training.

Participation as a part of this control group for this research is voluntary; there is no additional cost associated with your participation. If you decide to participate, your routine examination scores and routine performance scores will be used in this research. Performance will also be video recorded to ensure accurate data collection. As part of the research, you will be asked to complete an additional survey post training to obtain your opinion of the training you received. Time involved in this research will be no more than the time typically used in conducting a CPR training course with an additional 10 to 15 minutes needed to complete the survey.

As part of the research, you will be asked to complete the final examination and performance checks again 1 week after completing the course and another assessment 4 weeks after the secondary assessment to determine retention of the course content. This will take 10 to 25 minutes to complete.

All materials and any identifiable information will be encrypted and stored on password protected devices to ensure participants' confidentiality. Participation in this research does not determine your success or failure of this course, and you may withdraw at any time without penalty.

Page 1 of 3
Version Date: 05/23/13
Fall Control Group
Risks and Discomforts

There are minimal risks and discomforts in this study. Physical requirements are typical to routine CPR training. Any risk or discomfort will be related to routine CPR training expected while attending the American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course.

Benefits

This study will allow us to determine the usefulness of virtual reality as a teaching tool for CPR training. You may not benefit directly from taking part in this study. This research will expand the knowledge in both areas of CPR and the use of virtual reality as a learning tool. CPR has been proven difficult to learn and to perform correctly, which leads to more innovative ways to discover new and essential methods to teach CPR to improve retention, performance, and attitudes towards CPR. There have been many attempts to modernize CPR, and the use of virtual reality as a learning tool may provide a means to ease the change. Virtual reality has shown some educational benefits and assisting in describing complex processes or procedures in a visual way to help the user or person understand problems better.

Alternatives

Your alternative is not to participate in this study and complete standard CPR training.

Confidentiality

Information obtained about you for this study will be kept confidential to the extent allowed by law. However, research information that identifies you may be shared with the UAB Institutional Review Board (IRB) and others who are responsible for ensuring compliance with laws and regulations related to research involving people on the behalf of UAB Department of Medicine, Engineering, and the Office for Human Research Protections (OHRP). The results of the study may be published. However, your identity will not be given out.

Refusal or Withdrawal without Penalty

Whether or not you take part in this study is your choice. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with this institution. You may be removed from the study without your consent if the sponsor ends the study.

If you are a UAB student or employee, taking part in this research is not a part of your UAB class work or duties. You can refuse to enroll, or withdraw after enrolling at any time.
before the study is over, with no effect on your class standing, grades, or job at UAB. You will not be offered or receive any special consideration if you take part in this research.

**Cost of Participation**

There will be no cost to you for taking part in this study.

**Payment for Participation in Research**

There will be compensation of $40.00 after successfully completing the final phase of the study and all the required information. Compensation may also take up to 6 weeks and will be issued by mail in the form of a check made out to each participating individual that completes the research requirements.

**Questions**

If you have any further questions, concerns, or complaints about this study, you may contact Alanzo Granville at adgranvi@uab.edu, or (256)-483-0923.

If you have questions about your rights as a research participant, or concerns or complaints about the research, you may contact the Office of the IRB (OIRB) at (205) 934-3789 or 1-800-822-8816. If calling the toll-free number, press the option for an operator/attendant and ask for extension 4-3789. Regular hours for the OIRB are 8:00 a.m. to 5:00 p.m. CT, Monday through Friday. You may also call this number in the event the research staff cannot be reached or you wish to talk to someone else.

**Legal Rights**

You are not waiving any of your legal rights by signing this informed consent document.

**Signatures**

Your signature below indicates that you agree to participate in this study. You will receive a copy of this unsigned document.

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Informed Consent Document

TITLE OF RESEARCH: Construction of 3D Cardiopulmonary Resuscitation Emergency Scenarios for First Responder Pre-Nursing Training on Stereoscopic Display Systems

IRB PROTOCOL: X130207004

INVESTIGATOR: Alanzo D. Granville

SPONSOR: UAB Department of Mechanical Engineering

Explanation of Procedures

You are being asked to participate in a research study that examines experiences in CPR training. This study will measure both the retention and performance of participants during CPR training. Both measurements will be obtained using routine examination and routine performance check lists. Additionally, opinion surveys will be used to record attitudes towards training at the end of each session.

The purpose of this research study is to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. This research study will measure retention, performance, and attitude of pre-nursing students enrolled in American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course. This study will allow for a better interpretation of how the virtual environments can be used to reinforce student CPR training.

Participation as a part of this treatment group for this research is voluntary. The treatment group will include virtual reality as an enhancement tool to traditional CPR training. As part of the treatment group you will experience visual and auditory effects in a virtual environment. This treatment group will be placed into a four walled area that will allow for projectors to project images to mirror or duplicate an area of interest (i.e. apartment room, kitchen, etc.). These locations will be used to perform adult CPR on a half upper torso mannequin which is a part of the normal training. The CPR procedure will include the typically scenario explanation with at least the minimum cycles of chest compressions and breaths required for traditional CPR training with minor visual and auditory distractions.

If you decide to participate, your routine examination scores and routine performance scores will be used in this research. Performance will also be video recorded to ensure accurate data collection. As part of the research, you will also be asked to complete an additional survey post-training to obtain your opinion of the training you received. Time involved in this research will be at least the time typically used in conducting a CPR training course with an additional 10 to 15 minutes needed to complete the opinion survey.

As part of the research, you will be asked to complete the routine final examination and performance checks again 1 week after completing the course and another assessment 4 weeks.
after the secondary assessment to determine retention of the course content. This will take 10 to 25 minutes to complete.

All materials and any identifiable information will be encrypted and stored on password protected devices to ensure participants' confidentiality. Participation in this research does not determine your success or failure of this course, and you may withdraw at any time without penalty.

**Risks and Discomforts**

There are minimal risks and discomforts in this study. Physical requirements are typical to routine CPR training. Any risk or discomfort will be related to routine CPR training expected while attending the American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course.

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**Alternatives**

Your alternative is not to participate in this study and complete standard CPR training.

**Confidentiality**

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**Refusal or Withdrawal without Penalty**

Whether or not you take part in this study is your choice. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your

Page 2 of 3
Version Date: 05/23/13
Fall Treatment Group
choice to leave the study will not affect your relationship with this institution. You may be removed from the study without your consent if the sponsor ends the study.

If you are a UAB student or employee, taking part in this research is not a part of your UAB class work or duties. You can refuse to enroll, or withdraw after enrolling at any time before the study is over, with no effect on your class standing, grades, or job at UAB. You will not be offered or receive any special consideration if you take part in this research.

**Cost of Participation**

There will be no cost to you for taking part in this study.

**Payment for Participation in Research**

There will be compensation of $40.00 after successfully completing the final phase of the study and all the required information. Compensation may also take up to 6 weeks and will be issued by mail in the form of a check made out to each participating individual that completes the research requirements.

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Informed Consent Document

TITLE OF RESEARCH: Construction of 3D Cardiopulmonary Resuscitation Emergency Scenarios for First Responder Pre-Nursing Training on Stereoscopic Display Systems

IRB PROTOCOL: X130207004

INVESTIGATOR: Alanzo D. Granville

SPONSOR: UAB Department of Mechanical Engineering

Explanation of Procedures

You are being asked to participate in a research study that examines experiences in CPR training. This study will measure both the retention and performance of participants during CPR training. Both measurements will be obtained using routine examination and routine performance check lists. Additionally, as part of the research, opinion surveys will be used to record attitudes towards training at the end of each session.

The purpose of this research study is to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. This research study will measure retention, performance, and attitude of pre-nursing students enrolled in American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course. This study will allow for a better interpretation of how the virtual environments can be used to reinforce student CPR training.

Participation as a part of this control group for this research is voluntary; there is no additional cost associated with your participation. If you decide to participate, your routine examination scores and routine performance scores will be used in this research. Performance will also be video recorded to ensure accurate data collection. As part of the research, you will be asked to complete an additional survey post training to obtain your opinion of the training you received. Time involved in this research will be no more than the time typically used in conducting a CPR training course with an additional 10 to 15 minutes needed to complete the survey.

As part of the research, you will be asked to complete the final examination and performance checks again 4 week after completing the course to determine retention of the course content. This will take 10 to 25 minutes to complete.

All materials and any identifiable information will be encrypted and stored on password protected devices to ensure participants’ confidentiality. Participation in this research does not determine your success or failure of this course, and you may withdraw at any time without penalty.

UAB IRB

Date of Approval: 5/3/13

Not Valid On: 2/11/14
Risks and Discomforts

There are minimal risks and discomforts in this study. Physical requirements are typical to routine CPR training. Any risk or discomfort will be related to routine CPR training expected while attending the American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course.

Benefits

This study will allow us to determine the usefulness of virtual reality as a teaching tool for CPR training. You may not benefit directly from taking part in this study. This research will expand the knowledge in both areas of CPR and the use of virtual reality as a learning tool. CPR has been proven difficult to learn and to perform correctly, which leads to more innovative ways to discover new and essential methods to teach CPR to improve retention, performance, and attitudes towards CPR. There have been many attempts to modernize CPR, and the use of virtual reality as a learning tool may provide a means to ease the change. Virtual reality has shown some educational benefits and assisting in describing complex processes or procedures in a visual way to help the user or person understand problems better.

Alternatives

Your alternative is not to participate in this study and complete standard CPR training.

Confidentiality

Information obtained about you for this study will be kept confidential to the extent allowed by law. However, research information that identifies you may be shared with the UAB Institutional Review Board (IRB) and others who are responsible for ensuring compliance with laws and regulations related to research involving people on the behalf of UAB Department of Medicine, Engineering, and the Office for Human Research Protections (OHRP). The results of the study may be published. However, your identity will not be given out.

Refusal or Withdrawal without Penalty

Whether or not you take part in this study is your choice. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with this institution. You may be removed from the study without your consent if the sponsor ends the study.

If you are a UAB student or employee, taking part in this research is not a part of your UAB class work or duties. You can refuse to enroll, or withdraw after enrolling at any time.
before the study is over, with no effect on your class standing, grades, or job at UAB. You will not be offered or receive any special consideration if you take part in this research.

Cost of Participation

There will be no cost to you for taking part in this study.

Payment for Participation in Research

There will be compensation of $25.00 after successfully completing the final phase of the study and all the required information. Compensation may also take up to 6 weeks and will be issued by mail in the form of a check made out to each participating individual that completes the research requirements.

Questions

If you have any further questions, concerns, or complaints about this study, you may contact Alanzo Granville at adgranvi@uab.edu, or (256) 483-0923.

If you have questions about your rights as a research participant, or concerns or complaints about the research, you may contact the Office of the IRB (OIRB) at (205) 934-3789 or 1-800-822-8816. If calling the toll-free number, press the option for an operator/attendant and ask for extension 4-3789. Regular hours for the OIRB are 8:00 a.m. to 5:00 p.m. CT, Monday through Friday. You may also call this number in the event the research staff cannot be reached or you wish to talk to someone else.

Legal Rights

You are not waiving any of your legal rights by signing this informed consent document.

Signatures

Your signature below indicates that you agree to participate in this study. You will receive a copy of this unsigned document.

Signature of Participant __________________________ Date __________

Signature of Principal Investigator __________________________ Date __________

Signature of Witness __________________________ Date __________
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The purpose of this research study is to investigate the effects of virtual environments for CPR training by comparing replicated real emergency CPR scenario experiences between virtual training and traditional classroom training. This research study will measure retention, performance, and attitude of pre-nursing students enrolled in American Heart Association - Basic Care Life Support for Healthcare Providers with AED (Automated External Defibrillator) course. This study will allow for a better interpretation of how the virtual environments can be used to reinforce student CPR training.

Participation as a part of this treatment group for this research is voluntary. The treatment group will include virtual reality as an enhancement tool to traditional CPR training. As part of the treatment group you will experience visual and auditory effects in a virtual environment. This treatment group will be placed into a four walled area that will allow for projectors to project images to mirror or duplicate an area of interest (i.e. apartment room, kitchen, etc.). These locations will be used to perform adult CPR on a half upper torso mannequin which is a part of the normal training. The CPR procedure will include the typically scenario explanation with at least the minimum cycles of chest compressions and breaths required for traditional CPR training with minor visual and auditory distractions.

If you decide to participate, your routine examination scores and routine performance scores will be used in this research. Performance will also be video recorded to ensure accurate data collection. As part of the research, you will also be asked to complete an additional survey post-training to obtain your opinion of the training you received. Time involved in this research will be at least the time typically used in conducting a CPR training course with an additional 10 to 15 minutes needed to complete the opinion survey.

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Summer Treatment Group
As part of the research, you will be asked to complete the routine final examination and performance checks again 4 week after completing the course to determine retention of the course content. This will take 10 to 25 minutes to complete.

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choice to leave the study will not affect your relationship with this institution. You may be removed from the study without your consent if the sponsor ends the study.

If you are a UAB student or employee, taking part in this research is not a part of your UAB class work or duties. You can refuse to enroll, or withdraw after enrolling at any time before the study is over, with no effect on your class standing, grades, or job at UAB. You will not be offered or receive any special consideration if you take part in this research.

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Signature of Participant __________________________ Date __________

Signature of Principal Investigator __________________________ Date __________

Signature of Witness __________________________ Date __________
Mixed Reality CPR Emergency Scenario Participant Observation Notes

Treatment Group During Virtual Enhancement Training (Retesting Period One)

Participant 18 (1st in video sequence)

Did not perform:

*Check for pulse 5 to 10 seconds*

*Did not check for scene safety*

*Did not call 911*

The participant first looked around the scenario, therefore the participant did not verbalize that the scene was safe. The participant also did not see any virtual figure in the kitchen, so the participant did not consider asking someone or calling for 911. The participant also did not check for a cardiac pulse long enough, either he/she felt the urgent need to start compressions or forgot to perform hold for the pulse check. The participant said he/she did not notice anyone in the kitchen so she didn’t realize that we were still present and did not consider us as part of the scenario.

Participant 5 (2nd video in sequence)

Did not perform:

Performed out of order:

*Call for 911*

*Check for Consciousness*

The participant quickly looked around the scene, and responded to the victim as fast as possible with a minor out of order procedural mistake to start compression as soon as possible. As soon as the scene started she rushed to perform CPR. The participant also verbalized that the scene was safe while looking around the virtual environment. The participant verbalized call for 911 before checking to see if the person was conscious which was out of CPR procedure order. The participant also performed chest compression at a fast rate, but not too fast to allow the chest to recoil.

Participant 1 (3rd in video sequence)

Did not perform:

*Did not complete five cycles before 2 minutes elapsed*

Issue:

*Performed compressions too slowly*

*Used thumb when she check for the adult pulse*
Participant looked around the entire scene as well as verbalized that the scene looks safe. The participant did look around the entire scene, but was not able to complete the minimum number of compressions.

Participant 2 (4th in video sequence)

**Did not perform:**  
*Check for pulse 5 to 10 secs*

**Issue:**  
Worried about equipment while performing

As soon as the scene started the participant rushed to the victim, and looked and verbalized scene safety. The participant aggressively taped the victim to check for consciousness, as well as having an elevated voice to call for 911 and an AED. Also the participant rushed the pulse check to immediately start chest compressions. The tracker also fell and the participant attached the tracker back to his/her waist before resuming compressions (more user friendly equipment is needed).

Participant 12 (5th in video sequence)

**Did not perform:**  
*Did not call 911*

Participant slowly looked around the entire scene to check for scene safety. He actually looked around multiple times for area dangers.

Participant 19 (6th in video sequence)

**Did not perform:**  
*Did not check pulse for 5 to 10 seconds*

**Issue:**  
*Participant referred to the instructor to ask if she could keep going after the completion of three cycles.*

The participant seemed excited once the scene came up. Immediately the participant started to check for consciousness of the victim then physically staggered and remembered to check the scene for safety. The participant did not check the pulse long enough to immediately began chest compressions. The participant barely made the cut off time for 5 cycles by less than 5 seconds before scene stopped. Participant seemed very excited after training.

The participant commented, “I know. I was like whoa, wait a second this is really happening.”
Although the participant performed the call for 911 and check for responsiveness correctly during the simulation, the participant asked the instructor which one should you have completed first. The participant possibly could have performed the checks using instinct.

**Participant 9 (7th in video sequence)**

**Did not perform:**

**Issue:**
Out of sequence with determining unresponsiveness, calling 911, and checking for a pulse.

Participant motioned back and forth with hands near the waist area twice and verbalized checking the scene for safety while looking around. Virtual environment froze, but the participant did not notice it while checking for consciousness of the victim, although the floor remained intact during freezing the participant noticed nothing else. The participant became fixed on the victim after starting compressions, although from her view the environment remained intact due to the floor staying in place.

**Participant 14 (8th in video sequence)**

**Did not perform:**

As soon as the scene started the participant quickly hopped to the victim, kneeled down and reached towards the victim, then jumped back up before touching the victim and verbalized, “Check to see if the scene is safe”. Then the participant quickly kneeled back down to check for consciousness of the victim. The participant started to make sure that the airway was open, but then quickly adjusted realizing the procedure had changed from A-B-C to C-A-B. Then started fast compressions and allowing the chest to recoil. The pinned equipment tracker fell, but did not distract the participant. The participant actually quickly rechecked for a pulse after the third cycle of compressions. The participant seemed immersed in the training scenario immediately after the scene started.

**Participant 17 (9th in video sequence)**

**Did not perform:**

*Partially performed head tilt chin lift*

The Participant looked around the scene to check for scene safety. The participant seemed immersed in the training scenario immediately after the scene started.
Participant 21 (10\textsuperscript{th} in video sequence)

**Did not perform:**
No check for scene safety

**Issue:**
Out of sequence with determining responsiveness and calling 911

The participant seemed shocked in nervous upon entering the mixed reality simulation environment. The participant saw the virtual scene, quickly said, “Oh boy. Ok!” Even though the participant looked around before checking to see if the victim was response, the participant forgot to verbalize a check for scene safety. The participant checked for the victims pulse then stated, “You go get a ugh, you called the fire department and you go get an AED.” Instead of saying call 911. After the 2\textsuperscript{nd} cycle the participant completed the cycle and stated, “Still nothing” in reference to the victim remaining unresponsive. The participant seemed eager after completing the performance.

Participant 8 (11\textsuperscript{th} in video sequence)

**Did not perform:**

*Did not check for scene safety*
*Did not call 911*

The participant first looked around the scene, prior to reaching down to the victim. Then tap the victim for unresponsiveness, and looked back into the virtual scene. Then the participant checked the victim’s pulse. The participant did not verbalize a scene safety check. The participant seemed interested in looking around the scene to see what was there.

Participant 10 (12\textsuperscript{th} in video sequence)

**Did not perform:**

**Issue:**
*Almost went back to A-B-C CPR procedure, but didn’t*

The participant seemed very interested in his/her surroundings. The participant stated, “Oh” once the scene started. The participant looked back and upward around the scene once. Looked down at the victim, stepped towards the victim then immediately turn his/her head to look around the scene again then verbalized that the scene was safe. The participant then tapped the victim to determine responsiveness, and then looked around the scene again. The participant asked the instructor was there was anyone present in the room, since there was no virtual character present. The instructor then responded, ”I’m here.” The participant then started to check the
pulse, then briefly moved to open the airway and returned to the C-A-B CPR procedure. While performing compressions the participant glanced up at the virtual scene, then looked back at the victim repeatedly during the performance. After the third cycle the participant asked the instructor should he/she keep going. During the 5\textsuperscript{th} cycle the participant made it more evident that he/she was looking around the virtual environment while performing compressions on the victim.

<table>
<thead>
<tr>
<th>Participant 7 (13\textsuperscript{th} in video sequence)</th>
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<tbody>
<tr>
<td><strong>Did not perform:</strong></td>
</tr>
<tr>
<td><em>Did not seal the nose during giving breaths to the victim</em></td>
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<tr>
<td><strong>Issue:</strong></td>
</tr>
<tr>
<td><em>Called for help and pulse check was out of order.</em></td>
</tr>
<tr>
<td><em>Compression needed to be harder and more consistent.</em></td>
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</table>

The participant looked around the scene slowly, but did not verbalize that the scene was safe. The participant then checked the victim for consciousness, and called for 911. A segmentation fault randomly occurred in the system, but the system was instantly restarted so the participant no interruption. After three cycles the participant looked to the instructor to see whether to stop or not. Even after being told prior that the PI or instructor would tell the participant when to stop.

<table>
<thead>
<tr>
<th>Participant 13 (14\textsuperscript{th} in video sequence)</th>
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<tbody>
<tr>
<td><strong>Did not perform:</strong></td>
</tr>
<tr>
<td><em>Check for pulse</em></td>
</tr>
<tr>
<td><strong>Issue</strong></td>
</tr>
<tr>
<td><em>Compression were not near the correct depth.</em></td>
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Even though the participant was instructed prior to starting to start immediately when the scene appears, the participant looked around the scene from side to side then, “Asked should I just go?” There was no verbalization of scene safety. The participant walked towards the victim, then stopped, and asked the instructor questions about practice, in which the instructor responded yes. Initial the participant had difficult performing compressions, but as time progress the participant became better towards the end of the performance simulation during the 3\textsuperscript{rd}, 4\textsuperscript{th}, and 5\textsuperscript{th} cycles.

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<tr>
<th>Participant 4 (15\textsuperscript{th} in video sequence)</th>
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<tbody>
<tr>
<td><strong>Did not perform:</strong></td>
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The participant seemed interested in looking around the scene multiple times. The participant first looked around the scene, prior to looking down at the victim. The participant verbalized that he/she was checking to see if the scene was safe while looking around the virtual scene. Then tap the victim for unresponsiveness, and verbalized a call for 911. Then the participant checked the victim’s pulse and began compressions.

**Participant 16** (16th in video sequence)

**Did not perform:**

**Issue:**

*Out of sequence call for 911 and checking for victim consciousness*

The participant looked around the environment and checked for scene safety with verbalizing, and instructed a call to call 911 before checking for victim consciousness.

**Participant 3** (17th in video sequence)

**Did not perform:**

**Issue:**

*Out of sequence check for pulse and calling for 911*

*Compression during the participants first compressions were inefficient (corrected before end of the first cycle)*

The participant looked around the scene and verbalized that the scene was safe. The began to check the victim for consciousness.

**Participant 6** (18th in video sequence)

**Did not perform:**

*Did not call 911*

**Issue:**

*Difficulty with getting the correct compression depth and speed*

The participant first looked around the scene with verbalization, prior to reaching down to the victim. Then tap the victim for unresponsiveness. A segmentation fault occurred within the system, but did not interfere with the participant’s performance.

**Notes:**
The participant experience a segmentation fault

**Participant 15** (19th in video sequence)

**Did not perform:**

*Did not check for scene safety*

**Issue:**
Out of order check for pulse before calling 911

The participant first looked around the scene quickly, but did not verbalize that the scene was safe. The participant did an out of order check for pulse before calling 911.

**Participant 20** (20th in video sequence)

**Did not perform:**

The participant looked around the entire scene and verbalized scene safety. After the third cycle participant quickly did a pulse check and stated, "Still not breathing." Participant continued compressions for a few seconds after being instructed the he/she was finish. The participant seemed immersed in performing the CPR procedure during training.

**Participant 11** (21st in video sequence)

**Did not perform:**

*Did not call for 911*

The participant looked around the scene then looked to the instructor to start the process. Although the participant was instructed a few seconds prior to start immediately once the scene starts.