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I, Sharon L Farra , hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in Nursing - Doctoral Program.

It is entitled:

Effects of Disaster Training With and Without Virtual Simulation

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Effects of Disaster Training With and Without Virtual Simulation

A dissertation submitted to the

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by

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Abstract

Purpose

Disaster preparation of healthcare professionals is seriously inadequate. The purpose of this experimental study was to examine the longitudinal effects of virtual reality simulation (VRS) on learning outcomes and learning retention of disaster training with Associate Degree nursing students.

Research Design

The study employed a longitudinal experimental design using two groups and repeated measures. The participants were randomly assigned to either an intervention group (Web-based teaching method with VRS) or standard group (Web-based teaching only) for disaster training.

Methods

Participants were a convenience sample of second year Associate Degree nursing students enrolled in a disaster course. Consented subjects were randomized to two groups; one group completed Web-based modules alone. The other completed both the Web-based modules and a virtually simulated disaster experience. Learning was measured using a 20 question multiple choice assessment pre/post and at two months following training. To address the research questions and to assess the overall effect of the VRS the results of the assessment scores were analyzed by SPSS software using the generalized linear model, implementing generalized estimating equations. Independent and paired t-tests were used to examine the between and within participant differences.

Findings

Overall the main effect of the virtual simulation was strongly significant ($p < .0001$). Both groups showed similar improvement of scores following the teaching interventions on the first post assessment. However, significant differences were seen in the scores at two-months. The VRS effect demonstrated stability over time while the standard (non-simulation) group showed significant decay in scores.

Conclusion

In this preliminary examination, VRS is an instructional method that reinforces learning and improves learning retention. The use of VRS in disaster training may improve accessibility and cost effectiveness as an alternative to live drills. Further study is necessary in the use of VRS in disaster training and an exploration of areas of learning where VRS may be an applicable pedagogy in nursing education. Larger studies involving random samples and varied VRS delivery methods are essential. Studies are needed with more longitudinal data to explore the stability of the learning effect.

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Chapter I

Proposal: Effects of Disaster Training With and Without Virtual Simulation

All people have risk of direct involvement in a disaster. According to the United States Federal Emergency Management Agency (FEMA) (2011) there are approximately two federally declared disaster per week in the United States (U.S.). In 2011, there was a ten-year high of ninety-nine federally declared disasters. In the past decade, the U.S. has suffered numerous major disasters including those of both man-made and natural origins. Examples of these events include the events of 9/11, hurricane Katrina, wild fires in California, blizzards in the Eastern U.S. and many other declared disasters (FEMA, 2010). The effects of disasters outside the United States have also been devastating. Demonstrating the potential for destruction that exists daily in the world is the recent earthquake in Haiti, which inflicted mass casualties and property destruction. The estimated loss of life in this event was over 220,000 (World Health Organization, 2010). In another disaster, a major earthquake and tsunami has struck Japan with more than 16,600 victims missing or dead and with a resultant release of toxic levels of radioactive materials (United Nations Office of the Coordination of Humanitarian Affairs, 2011).

There is an ever-present danger of disaster occurring within and outside the borders of the U.S. Effective emergency response to these disasters is a challenge to responsible agencies. A critical component of disaster preparedness is the training of the healthcare workforce (Joint Commission, 2006). Yet, there are continuing gaps in the education of nurses in preparing for disaster response (Chapman & Arbon, 2008; Slepiski & Littleton-Kerney, 2010). The lack of disaster training opportunities is one challenge to preparedness. Live exercises are expensive and difficult to organize, but virtual environments may offer an accessible and economic tool to meet training needs. The evolution of telecommunication technologies, Web-services and

software engineering has opened the virtual world with synthetic representations of reality that can help provide realistic training exercises (Chen, Rebooledo-Mendez, Liarokapis, de Freitas, & Parker, 2008). This study offered an innovative approach to educating nursing students to respond to disasters. The dissertation contains three manuscripts. The presentation of the dissertation is as follows: Chapter One is the research proposal, Chapter Two contains the first manuscript, an integrative review of the literature, Chapter Three is the second manuscript, a report of the study and findings, Chapter Four is the third manuscript which is a discussion of translation to practice, and Chapter Five contains the summary and conclusion.

Specific Aims

The long-term goal of this proposal was to assess the effectiveness of disaster preparedness education by measuring knowledge acquisition and retention of disaster training augmented with a virtual reality disaster experience. If virtual reality simulation was found to be an effective method of delivering disaster training, it could lead to improvements in the preparedness of disaster training participants. Situated learning theory supports the use of virtual simulations in increasing learner's knowledge and retention (Bares, Zettemoyer, & Lester, 1998). This theory is based upon concepts of embodiment (cognition is dependent on the sensorimotor brain and body), embeddedness (cognition is fixed in context specific representations) and extension (cognitive systems exist in a physical and social environment) (Robbins & Aydede, 2009). When situated cognition occurs, learners who are immersed in the context of their domain of learning have better learning outcomes (Brown et al., 1989). Given the prevalence of disasters in our country, the federal government is spending millions of dollars on the development of virtual simulations to augment disaster and other learning experiences, but there is little research validating their efficacy as a learning tool (Hansen, 2008). The purpose of

this innovative study was to examine the effectiveness of virtual reality disaster simulation in fostering knowledge acquisition and retention of disaster training in nursing students.

To facilitate better understanding of the study the following definitions are included for clarity:

- Disaster: A natural or man-made event needing resources outside of the local community to respond to the event (World Health Organization (WHO), 2005). For the purposes of this study, a disaster was defined a mass casualty incident (MCI) resulting in a response beyond that of the local community (Slepski, 2005).
- Disaster Training: In the study, the focus of disaster training is on nursing care of direct patient care issues of victims of a disaster. Training includes the “knowledge and skill to recognize the potential for a Mass Casualty Incident, identify when such an event may have occurred, know how to protect oneself, know how to provide immediate care for those individuals involved, recognize their own role and limitations, and know where to seek additional information and resources” (International Nursing Coalition for Mass Casualty Education, 2003 para. 1)
- Web-based learning: Learning materials, which are presented to the learner via Web browser (Tsai & Machado, 2002).
- Virtual reality simulation: Computer simulation of a three dimensional physical environment which includes both visual and auditory stimuli, with and within, which an individual can interact and effect the simulation (Encarta, 2009).
- Learning: The acquisition of new knowledge or meanings after an experience (Ausubel, 2000).

- Learning retention: The process of maintaining the availability of new knowledge. It includes the ability to store, retain and recall received information in memory. The time of retention may be short (days) or may be unlimited (Ausubel, 2000).

For the purposes of feasibility of the study, retention was assessed at two months post learning experience.

The first specific aim of the study was to:

Compare the effectiveness of disaster training augmented with virtual reality disaster simulation to Web-based training alone in promoting learning.

The first research question considered was:

1. Are there differences in knowledge of disaster response when comparing participants who received Web-based disaster training and those who received Web-based training and a virtual disaster simulation experience?

It was hypothesized that participants who received Web-based disaster training augmented with a virtual reality disaster simulation experience would have increased learning of disaster response strategies.

The second specific aim of this study was to:

Compare the effectiveness of Web-based disaster training augmented with virtual reality disaster simulation to Web-based training alone in promoting learning retention.

The second research question considered was:

1. Are there differences in retention of knowledge of disaster response when comparing participants who received Web-based disaster training and those who received Web-based training and a virtual simulation experience?

It was hypothesized that participants who received Web-based disaster education augmented with a virtual disaster simulation experience would have increased retention of learned disaster response strategies.

Research Strategy

Significance

The United States government has invested millions of dollars into the development of virtual reality simulation, but limited research has been done on its efficacy as an instructional tool (Wilson & Phipps, 2006). The Center for Disease Control and Prevention (CDC) (2010) and the Joint Commission (2006) emphasize the need for preparedness including training to mitigate the consequences of disaster. In a systemic review of the literature evaluating the effectiveness of training for health care workers, Williams, Nocera and Casteel (2008) found that the available evidence is insufficient to determine whether disaster-training interventions for health care providers are effective in improving knowledge and skills in disaster response. In another study of disaster training, Fox and Timm (2008) found that although professional nurses had improvement in test scores following pediatric disaster training, there was decay in test scores two-years post training.

Without a properly prepared healthcare work force, mortality and morbidity will increase following disaster (CDC, 2010). Training methods are needed which are effective, accessible and affordable to healthcare workers. Virtual simulation training may offer a cost effective and reliable teaching method of delivering training. Development of a body of evidence related to the effectiveness of this training is needed to fill this gap in the literature.

Review of the literature

The World Health Organization (WHO) describes a disaster as a natural or man-made event needing resources outside of the local community to respond to the event (WHO, 2005). These scarce resources often include both supplies and personnel needed to deliver health care (Slepski, 2007). The CDC (2010) has identified a strategy to mitigate the effects of disaster which includes both public health preparedness and medical preparedness. The health care system must be able to “prevent, protect and quickly respond to, and to recover from health emergencies” (CDC, 2010, para 3). Health care workers represent the largest sector of those who respond in the event of disaster (Hsu, Thomas, Bass, Whyne, Kelen & Green, 2006; Ablah, 2009). There are over fourteen million healthcare workers in the United States (Bureau of Labor Statistics, 2010). One strategy to improve the health care system response to disaster is by providing training for health care workers (Spleski, 2007, Hsu, et. al, 2006). Nurses represent the largest portion of the healthcare workforce (Bureau of Labor Statistics, 2010). Therefore, effective disaster planning and preparedness requires training of professional nurses for disaster response.

Considine and Mitchell (2009) found in their study of emergency nurses preparedness perceptions that nurses believed that significant deficiencies existed in disaster training. The authors identified a need for adequate staff training in biologic, chemical and radiologic incidents. Leaders within the nursing profession have identified a need for disaster training of nurses. The International Nursing Coalition for Mass Casualty Education (INCMCE) (2003) calls for the education of all nurses in disaster preparedness and the addition of mass causality incident management in nursing school curricula.

Both the American Nursing Association (2002) and the American Association of Colleges of Nursing support mandatory training of nursing students in disaster preparedness, yet neither agency has recommended specific content for this training. Unfortunately, there has been no formalized curriculum developed to prepare nursing students to respond to disasters (Slepski & Littleton-Kearney, 2010). There are also no federally established criteria for disaster education of nursing students. In 2003, INCMCE gathered a group of nursing experts and stakeholders to identify the competencies required for entry-level registered nurses in mass casualty incidents (MCI). These competencies are directed towards the nursing generalist and are focused on direct care of initial survivors of a disaster. The INCMCE (2003) suggests that nurses have sufficient knowledge and skill to: 1) identify the risk for a MCI, 2) determine when such an event may have occurred, 3) know how to protect themselves, 4) be able to provide immediate care for those individuals involved, 5) understand their own role and limitations, and 6) be familiar with methods of accessing additional information and resources.

One method to deliver disaster education is by virtual reality simulation. Chen et al. (2008) describe virtual simulation as the use of shared space, graphic user interface, immediacy, interactivity and persistence. Virtual simulation allows the use of 3-D environments and computer interface to allow participants to interact with a virtual environment (Bergeron, 2008). There are a variety of methods used for the delivery of virtual disaster education. An intelligent tutoring system based upon gaming technology has been used to train nuclear event first responders (Bergeron, 2008). Vincent, Sherstyuk, Burgess and Connolly (2008) used immersive virtual reality with head-mounted display and motion tracking sensors to teach medical students mass casualty skills. Kurenov et al. (2009) used interactive video game-based training modules with avatar representation and keyboard interface to teach mass casualty burn treatment.

Wilkerson et al. (2008) used a combination of cave automatic virtual environment and a high-fidelity human patient simulator to train first responders for mass casualty incidents. Heinrichs, Youngblood, Harter, and Dev (2008) used 3-D virtual world technology in a multiplayer online format to train medical personnel in a mass casualty incident.

A review of the literature was conducted to find the current state of the science related to disaster training and virtual reality simulation. There are few articles that served to inform this study proposal; a total of twelve research articles were found addressing virtual simulation and disaster training. Findings of these studies fell into two general categories: learner perception of the virtual experience and outcomes of virtual disaster training. According to Heinrichs et al. (2008) participants in a virtual disaster simulation found the experiences to be adequately realistic with a feeling immersion or were able to “suspend disbelief”. Participants also found the training to be useful for learning both teamwork and clinical skills. Wilkerson et al. (2008) reported positive participant observations of virtual disaster training including feeling immersed in a realistic learning environment.

Learning outcomes of virtual disaster training were reported for the following studies. Vincent et al. (2008) found that after virtual disaster training participants had significantly improved self-efficacy in the areas of prioritizing treatment, prioritizing resources, identifying high-risk patients, and beliefs about learning to be an effective first responder. Novice learners also demonstrated improved triage and intervention scores, speed, and self-efficacy during an iterative, fully immersed virtual triage experience. Although the study reported positive results there were no discussion of the reliability and validity of the instruments used to measure either the triage scores or the reported self-efficacy tool.

Kurenov et al. (2009) report that preliminary results indicate that there is a positive correlation between training with the virtual Burn Center and performance in a traditional lectured course. However, no information is provided by the authors regarding the strength of the correlation. Wilkerson et al. (2008) found that training in a virtual environment has the potential to be a powerful tool to train first responders for high-acuity, low-frequency events, such as a terrorist attack. The findings demonstrate that virtual emergency department environments provide repeated practice opportunities in diverse locations with uncommon situations. Within these environments, learner's performances on cognitive and psychomotor tests were equal to or better than those who participated in traditional teaching methods. Andreatta et al. (2010) found that medical students receiving START triage training via CAVE virtual simulation had similar learning outcomes to those participating in live drills. Measurement of learning retention was performed in only one study, at six weeks post simulation experience and was measured by cognitive testing. Bergeron (2008) found that there was no decay in triage scores six weeks following virtual disaster game-based training, which contrasts with results expected with traditional training alone.

Overall, sample selection and size limited these studies. None of the studies discussed randomization in selection or placement in groups. Generally, the sample sizes were very limited, less than twenty-five participants, although one study included forty participants (Bergeron, 2008). The generalizability of these study's findings is restricted and additional studies with larger, randomized cohorts should be conducted. Most of the study designs used pre-post test tools to determine knowledge acquisition, but this assessment usually occurred immediately following the intervention. Only one study examined knowledge retention. Bergeron (2008) found that virtual simulation involving disasters had a positive effect on

simulation, but was limited to observation at only six weeks post experience. Future studies should examine participant retention at differing time intervals post intervention.

Instrumentation within the studies was also a threat to the rigor of the research. The authors administered self-developed study tools. These tools lacked discussion of tool development, reliability or validity. In this study, pre and post assessments were used. The multiple-choice questions were reviewed and revised by disaster experts to provide content validity and question construction was evaluated by education experts.

A final concern from the review of the literature was the under representation of registered nurses (RN) as participants. RN's comprise the largest portion of the healthcare workforce. The INCMCE (2003), the American Nurses Association (ANA) (2010) and the Joint Commission (2006) recognize the integral role that nurses play in any disaster and encourage RN preparedness and training. Nurses benefit from a well-trained response team professionally and personally. Studies, which help in the development of effective disaster training using virtual simulation, may increase the ability of nurses to participate in an active learning exercise to reinforce learned content. Unfortunately, only one of the reviewed studies included nurse participants (total of 6 participants).

In summary, researchers have clearly identified that traditional methods have not been proven to be effective in adequately preparing healthcare workers for disasters (Williams, Nocera & Casteel, 2008). Alternative teaching strategies, such as virtual simulation, need to be investigated as a means of providing disaster training. The use of virtual simulation as a means of education for healthcare workers is well supported in the literature. In their critical review of simulation-based medical education, McGaghie, Issenberg, Pertusa & Scalese (2010) reported that instruction which uses virtual reality simulation increases immediate and long-term

knowledge and learning post experience. McGaghie et al. (2010) reinforce the need for research of simulation methods and their effectiveness in training health care workers so that effective curriculum and simulations may be developed.

Implications for Health

Mortality and morbidity will increase following disaster without properly prepared healthcare workers (Hsu et al., 2006). Training methods are needed which are accessible and affordable to healthcare workers. Virtual simulation training may offer a cost effective and sound teaching method for delivering training. There is a need to develop a body of evidence related to the efficacy of virtual simulation training. Nurses comprise the largest portion of the healthcare workforce. The National Nursing Emergency Preparedness Education Coalition (2003) and the American Nurses Association (ANA) recognize the integral role that nurses play in any disaster. The ANA (2010) “encourages nurses to strengthen the capacity of the health services in emergencies by joining a volunteer registry” (para 1). Nurses benefit from a well-trained response team professionally and personally. Studies, which help in the development of effective disaster training using virtual simulation, may increase the ability of RN’s to participate in an active learning exercise to reinforce learned content. As RN’s represent the largest portion of the healthcare workforce, they must be better represented in disaster training research, particularly in virtual environments, so that a body of evidence can be built regarding the effectiveness of this training method with RN participants.

Theoretical Framework

Situated learning theory offered an effective framework for examining virtual reality simulation and knowledge acquisition and retention. Situated learning is a method of instruction in which the learner is placed into the situation that they are studying (Brown et al., 1989).

Concepts of learning should be presented in a realistic context, such as the situations and settings that would normally include that knowledge. Brown et al. (1989) proposed a model of instruction consisting of situation cognition and the culture of learning. The culture of learning is the community or culture in which acquired knowledge will be used. For example, the scalpel cannot be used appropriately without understanding the community or culture of the operating room. The authors asserted that meaningful learning would only take place if it were embedded in the social and physical context within which it would be used.

Cognitive apprenticeships serve to “enculturate students into authentic practices through activities and interaction” (Brown et al., 1989, p. 37). Learning takes place as the learner engages and practices within an environment where the knowledge developed is applied. Current nursing education has as a foundation the situated learning model. Clinical rotation models have student nurses placed on nursing units, participating in learning situations within the context of nursing practice. By engaging in the nursing activities that are being studied, the student nurse gains knowledge through situated learning (Lave & Wenger, 1991). According to Brown et al. (1989) students become engaged through enculturation in the environment of learning, by performing authentic activities of the community and learning through cognitive apprenticeships with experienced practitioners. Nursing students are embodied by involving their sensimotor centers in the brain in coordination with the body as they perform nursing activities. Embeddedness occurs as knowledge is acquired within contextual representations as it is applied in the health care environment. Extension is achieved as the student nurse interacts within the physical and social environment with other nurses and health care workers (Robbins & Aydede, 2009).

Educational technology has been supported as an avenue to bring situated learning into the classroom, through virtual reality and interactive multimedia (Harley, 1993). An interactive virtual environment offers a three dimensional environment in which learning can occur within a situated context. Appropriately, constructed virtual reality simulations provide authentic context, activities and opportunities to investigate multiple roles and perspectives. Heinrichs et al. (2008) found that participants experiencing a virtual disaster simulation believed the environment adequately realistic with a feeling of immersion or were able to “suspend disbelief” during participation. Providing virtual disaster training allows learners to practice and interact with situations to acquire knowledge of disaster response. These simulations offer greater opportunities for experiential learning, increased engagement, and improved contextualization of learning. There are a lack of studies that examine the dosing and timing of virtual simulation as an educational intervention. In other simulation research, Kardong-Edgren, Oermann, Odom-Maryon, and Ha (2010) found in a study of cardiopulmonary resuscitation (CPR) that nursing students were able to improve knowledge and skill performance of CPR using a simulator. Students, who practiced for as little as six minutes a month using a simulator, were able to retain or improve skills at twelve months. The control group, which received only the initial training, had decay or loss of skills within a few months of training. Providing increased opportunities for simulation practice may increase learning retention as learners are able to apply the knowledge repeatedly to situations.

Learning theorists have moved from the traditional emphasis on rote learning and memorization. Today many educators have a constructionist view of learning which underscores learning creation through building concepts. Students learn by doing. Knowledge is constructed individually and co-constructed socially by learners based on their interpretations of experiences

in the world. The learner's role shifts from passive to active as he or she acquires new concepts and procedures (Piaget, 1954). Founded in constructionist viewpoint, situated learning is one method of education delivery that lends itself well to virtual simulation. According to Herrington and Oliver (1995), virtual simulations "provide a powerful acceptable vehicle for the critical characteristics of traditional apprenticeship" (p.2). To be effective these virtual simulations must have the following characteristics as multimedia:

- Provide authentic context that reflects the way the knowledge will be used in real-life
- Provide authentic activities
- Provide access to expert performances and the modeling of processes
- Provide multiple roles and perspectives
- Support collaborative construction of knowledge
- Provide coaching and scaffolding at critical times
- Promote reflection to enable abstractions to be formed
- Provide for integrated assessment of learning with the tasks (p.3)

Situated learning is supported by work being done in the field of neuroscience on the development of memory. Kandel (2006) describes the neurophysiology of the brain and the development of procedure memory. Mirror neurons in the psychomotor cortex fire when an individual performs an activity; new pathways are developed within the brain. More pathways are formed during participative learning activities than through lecture alone (Kandel, 2006). Virtual simulation offers the opportunity for participants to perform activities which facilitate memory formation. In the context of this study, as the individual participates in the simulation activity they have enhanced memory retention of disaster response learning content.

It was assumed in the study that participants were motivated to learn and would be engaged in the virtual learning experience. The literature reports that learners feel engaged and involved when participating in virtual reality simulation. Jarmon, Traphagan, Mayrath, and Trivedi (2009) found in their mixed methods study of virtual reality in simulation, that the virtual reality environment supported experiential learning outcomes. Learners felt immersed in a realistic environment and engaged in learning. Overall, learners believed that virtual reality simulation offered an effective and realistic method of mastering concepts. Other studies report virtual simulations support the participant's ability to suspend disbelief and fully participate in the virtual experience (Bergeron, 2008; Herinrichs, Youngblood, Harter & Dev, 2008).

Innovation

The use of virtual simulation is an innovative approach to providing education. The United States Department of Homeland Security and North Atlantic Treaty Organization (NATO) Allied Command Transformation are both delivering training using virtual reality simulation (Department of Homeland Security, 2010). Virtual simulation offers a newer approach to disaster training that has well documented educational outcomes and effectiveness in other healthcare applications. Several studies exist in the literature examining the use of virtual reality simulation and the acquisition of surgical skills (Liu, Tendick, Cleary, & Kaufmann, 2003; McGaghie, Issenberg, Petrusa, & Scalese, 2010). In addition, virtual reality simulation is increasingly being used as a mode of training in other healthcare settings, yet it has not been well studied in the context of disaster training. The virtual reality simulation makes an important contribution to the development of disaster training by offering opportunities for disaster training in environments that closely simulate disaster situations. Effectively developed virtual disaster simulation will improve access and cost effectiveness of disaster training. To be successful in

providing realistic training the virtual disaster needs to have simulation fidelity (realistic presentation of situation), integration of curricular content, competency based learning, deliberate practice, feedback, outcome measurements and instructor training (McGaghie et al., 2010).

Approach

This experimental study was designed to investigate and evaluate the impact of a virtual simulation experience on learning and retention in disaster training. To accomplish this, two specific aims were proposed. The first was to examine the virtual simulation effect on immediate post-intervention learning. The second was to examine the virtual simulation effect on learning retention at two-months post intervention. Within the study, disaster training was the independent variable and learning and retention were the dependent variables. This section describes the research design, setting, participants, procedures, instrumentation, and data analysis.

Design.

The study was a longitudinal experimental design using two groups and repeated measures. The participants were randomly assigned to either the intervention group (traditional teaching method only) or standard care group (traditional teaching with virtual simulation group) for disaster training. The experimental design provided support for a cause-effect relationship between treatment and outcome (Shadish, Cook, & Campbell, 2002). Repeated measures designs are much more powerful than completely randomized designs because of the reduced error variability resulting from individual differences (Stevens, 1992). The independent variable for the control group was the Web-based modules alone; for the intervention group Web-based training augmented with a virtual reality simulation. The dependent variable was the acquired

learning as measured by a multiple-choice pre-assessment and post-assessment and a multiple choice assessment at two-months post intervention to assess learning retention.

Setting.

The setting was a Midwest Community College with an enrollment of approximately 26,000 students. The Web-based education intervention including pre/post /2-month assessments were delivered online via the Angel course management system of the college (Blackboard, 2012). The virtual simulation was delivered via the internet within the Second Life virtual environment (Second Life, n.d.).

Participants.

Participants were second year Associate Degree nursing students enrolled in either the capstone or pediatric nursing courses at a community college in Dayton, Ohio. Students ranged from 18-57 years of age. The population was 73% white, 18% African American and 7% Asian and 2% Hispanic. The majority of the students were female 91% and 9% were male (Marcia Miller, personal communication, May 5, 2010).

Sample size.

An *a priori* power analysis was computed to determine the required sample size for a two group (Treatment vs. Control) repeated measures design with three measurement intervals (i.e., Pre-Test, Post-assessment and 2 months follow-up). G-power analysis was used anticipating an ANOVA repeated measures, within-between interaction design ($\alpha=.05$, and a power of .80) (Faul, Erdfelder, Lang, Buchner, 2009). The effect size of the intervention was undetermined so multiple analysis were performed using effects size ranging from 0.15 to 0.45. The correlation among the repeated measures was also unknown so sample sizes were calculated for correlations of 0.2, 0.4, 0.6 and 0.8 (See Table 1). For the purposes of feasibility a sample of 32 (16 in each

group) was preferred. With this sample size, a statistical significance between groups would be demonstrated for an effect size ranging from small (auto correlation 0.8 or larger) to large effect sizes (see Table 1). Elliot, Holland and Thomson (2008) identify a response rate of 77.5% as the “gold standard” for longitudinal response. To account for potential attrition from the study, the desired sample size was increased by 22% with a total N of 39.

Table 1: Sample Size Estimate			
	.15 effect size	.30 effect size	.45 effect size
0.2 average auto correlation	116	32	16
0.4 average auto correlation	88	24	12
0.6 average auto correlation	60	16	10
0.8 average auto correlation	22	10	6
*shaded areas indicate possible undetectable significance with sample size of 39			

Sampling.

Recruitment of participants occurred through email solicitation and a general announcement placed on the Student Community Discussion Board and course announcements via the Angel learning management system to all students enrolled in either the pediatric or capstone nursing course (Blackboard, 2012). Both the informed consent and recruitment letter were presented, explained and distributed in each class section (See Appendix A & B). Inclusion criteria were participants be English speaking, eighteen years of age and enrolled in the pediatric or capstone nursing course. Exclusion criteria included previous disaster training certification, paramedic training, or physical limitations which would prevent participation in a virtual simulation using a computer monitor, mouse and keyboard.

Students who expressed interest in participating were directed towards “Simulation Study” modules on the Angel course management system (Blackboard, 2012). Those who chose not to participate were directed towards “Traditional Modules”. The participants who chose the “Simulation Study” were randomized into two groups using the random team generator within the Angel course management system. Randomization increased the statistical probability of having matched groups.

After accessing the research study modules students were again presented with the consent/information sheet. After indicating agreement to participate by checking the box “yes” response, students were directed to the pre-assessment (See Appendix B). The first question on the pre-assessment was a self-selected identifier which the participants recorded with each assessment. The identifier allowed individual results to be correlated. It was retrievable with each test so that participants could access their previously used identifier (in case it was forgotten). The inclusion questions regarding previous training and age were also presented with the first assessment. To protect anonymity course tracking was turned off and assessments were anonymous. There was no method by which instructors would know if students had chosen to participate in the research study. Upon completion of the final assessment, a completion certificate was automatically emailed to the participants. To compensate for the participants time, the certificate could be turned into the secretary in the nursing office for a ten-dollar Starbucks gift card.

Web-based education.

The first component of the educational intervention was the Web-based learning modules. There were five sets of modules developed from the learning objectives recommended by the International Nursing Coalition for Education for Mass Casualty Education (2003).

Modules were directed towards an understanding of clinical issues focused on aspects of direct nursing care of victims. Included were concepts of detection, personal protection and immediate care for those impacted by disasters. There was also a focus on preparing nurses with the resources to seek additional information and to recognize the need for assistance. Each module included a pre-assessment and post-assessment consisting of a total of 20 identical multiple-choice questions. Module 1 presented content related to incident command and casualty triage including decontamination. Module 2 content was chemical weapons including types, effects and treatment. Module 3 presented biological agents, Module 4 was radiologic events and Module 5 was explosive events and natural disasters. The modules consisted of textual narration, embedded active learning strategies such as practice questions, labeling activities and scenarios. See Appendix D for details of modules objectives, content, methods and evaluation.

The pre/post-assessment questions and learning modules were initially developed by the study author who is a certified disaster instructor. The questions were reviewed and revised by three disaster content experts for content validity and three educational experts to review the structure and format of the test items. Questions were designed to reflect learning at the domain levels of knowledge, comprehension, and application (Bloom & Krathwohl, 1956). Based upon feedback from the expert panel questions were revised and then resubmitted to the group for additional feedback. To limit academic dishonesty students were prompted to agree to conduct themselves with academic honesty by checking the box on an academic honesty statement (Adkins, Kenkel & Lo Kim, 2005). See the instrumentation section for the assessment development protocol.

Virtual simulation intervention.

A virtual simulation was developed to reinforce the Web-based learning presented in the online modules. The virtual simulation was delivered via the internet through the virtual reality program, Second Life (Second Life, n.d.) system. The simulation took approximately twenty minutes to complete. The simulation content was developed by the study author and reviewed by three disaster experts for authentic of activity, correctness of modeling processes, and the appropriateness of roles and perspectives (See Appendix E). Three education experts assessed the simulation for its ability to: a) support construction of knowledge b) effectiveness of coaching and scaffolding c) the scenario ability to promote reflection and abstraction and d) integration of assessment of the learning tasks (Herrington & Oliver, 1995). After the simulation script had been reviewed and revised, the simulation was articulated into the 3-D environment using the Second Life platform (Second Life, n.d.). A tutorial was designed for use with the module to familiarize the participants with the virtual environment.

Procedure.

Second year students in the pediatric and capstone course were invited to participate in the disaster training. Consented participants who met inclusion criteria were randomized into two groups. Both groups participated in the required online Disaster training including the pre and post multiple choice assessments.

The control group completed training at this point. Two months post intervention, the control group received email reminders to complete the final multiple choice assessment. The assessment was available on the internet delivered using the Angel Website for a period of seven days.

After completion of Disaster training, the treatment group was prompted to access the virtual reality simulation. There was a short orientation to the simulation and then students participated in a virtual reality simulation experience reinforcing the concepts of disaster triage and decontamination. Using a computer with internet capability, mouse and keyboard learners accessed two virtual disaster scenarios. The simulation began with a short tutorial; each scenario lasted approximately ten minutes. The participants assessed, triaged, decontaminated and provided first aid to victims of radioactive and explosive events. The virtual simulation offered both summative and cumulative performance feedback during and after each scenario and reinforced concepts taught in the Disaster course. After completing the virtual simulation, participants were asked to complete the online post assessment and another at two months. An email reminder sent to all participants prior to the opening of the two month post assessment. The assessment was open for completion for seven days and then was closed to participants. After completion of all three assessments, within the two-month time frame, all participants (control and treatment groups) could receive a Starbucks gift card to compensate their time. Table 2 is a representation of the procedure:

Table 2: Procedure			
	Pre-Assessment	Treatment/ Post Assessment	2 months
Random	Assessment ₁	Assessment ₂	Assessment ₃
Assignment	Assessment ₁	Assessment ₂	Assessment ₃

Instrumentation.

The pre/post assessment questions and learning modules were initially developed by the study author based upon the course objectives for the Web-based modules. The multiple-choice questions currently address the knowledge/comprehension (20%) and application (80%) levels of Bloom's (Bloom & Krathwohl, 1956) (See Appendix F). Questions were reviewed and revised by consultants with an expertise in disaster training for content validity. Educational experts reviewed each question using the taxonomy of multiple-choice item writing guidelines (Haladyna, Downing & Rodriguez, 2002). Revisions were made as needed. Five areas were examined including: content, formatting, style, the stem, and the choices. The cognitive level of each question was also validated. The following represents the protocol for review of the test questions (Figure 1).

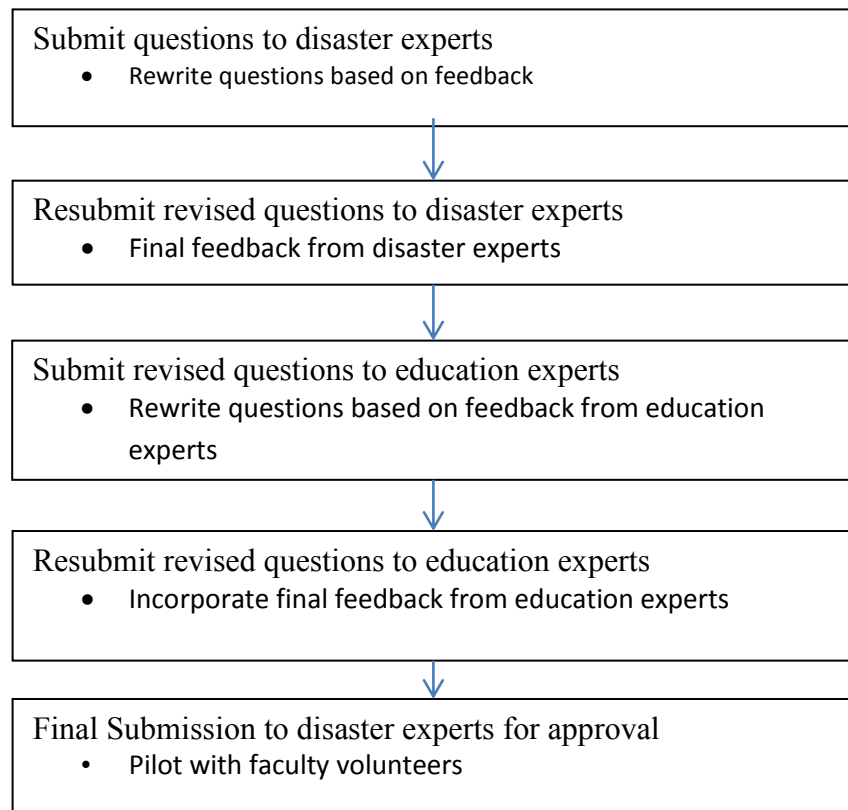


Figure 1: Question review protocol

Time frame.

The following was the study time frame:

Table 3: Time Frame																		
Activity	Year 1												Year 2					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Documentation Development	x	x	x	x	x	x												
Funding/IRB					x	x												
Enrollment								X	X									
Data Collection#1										x								
Data Collection #2										x								
Data Collection #3												x						
Data Analysis											x	x						
Dissemination													x	x	x	x	x	

Data analysis plan.

Data entry verification was accomplished using selection of randomly selected records after each session to check entry with a final sample examined at the end of the study. Prior to statistical analysis data was examined for missing data and outliers. Because the assessment was administered in a computerized format no missing data was found.

It was hypothesized that participants who received traditional disaster teaching methods augmented with a virtual disaster simulation experience would have increased learning and

retention of disaster response strategies. The results of the test scores were analyzed by SPSS software using the generalized linear model, implementing generalized estimating equations (GEE). There were two independent variables (teaching method), one repeated across all participants and the other a randomization to independent groups. The independent variables were the teaching method, either traditional or traditional and virtual simulation. The dependent variable was learning and learning retention. The dependent variables were measured by the results of the assessment scores. A critical alpha level of .05 was used to demonstrate statistical significance. Descriptive statistics (e.g., frequencies, percentages) were reported to describe the study population. Histograms of important variables were plotted and examined for extreme violations of the distributional assumptions for the statistical tests. Knowledge acquisition and retention were compared for within and between participant differences (pre-assessment data, post-assessment data) (alpha 0.05) using independent and paired *t*-tests.

Data management.

All data will be kept confidential. No stored data is attached to a participant's name. To ensure data security, a professionally trained computer and security expert maintains the server, which is housed and maintained at the College of Nursing at the University of Cincinnati which is a controlled access area. The data are backed up nightly to a different backup server, and archived to an encrypted tape that is taken off-site every week.

Scope and Limitations

The research project could have been limited due to sample attrition. The project ran over a two month time span, there was an increased risk of participant withdrawal or failure to complete the study. For this reason the sample size was increased by 25%. Participants were reminded to complete the questionnaire using email reminders. There was also the possibility of

academic dishonesty that could affect the results of the study. The possibility of dishonesty was lessened by study design which included acknowledgement of an academic honesty statement (Adkins et al., 2005).

Another possible limitation to the study was failure of the participants to complete the questionnaires in the allotted time. Varying the times of completion of the questionnaire would threaten the internal validity of the study. For this reason, the assessments were open for completion only during specified time periods of seven days.

Historical effects would have potentially impacted the outcome of this study (Houser, 2007). Fortunately there were no major disasters, which directly affected the students during the time period of the study.

Human subjects

Solicitation to participate with an information letter describing human subjects' protections and participant consent was distributed and reviewed with participants by the investigator. Study participation was voluntary. Participants were not paid for their participation, a Starbucks card was offered as compensation for participant's time. To protect participant confidentiality, all assessments were anonymous with tracking turned off within the course learning management system. Participant names are not the study data. Upon completion of the study, the course was deleted from the server. Data was downloaded onto a Federal Education Rights and Privacy Act (FERPA) compliant and password protected research server accessible only to the research team. To ensure data security, a professionally trained computer and security expert maintains the server, which is housed at the College of Nursing at the University of Cincinnati. Access to the database at the University of Cincinnati is password-protected and known only by the investigator.

Student participants are a vulnerable population and caution was taken to protect their rights. Students were not pressured to participate and their grade was affected by either their participation or non participation in this research study. It was impossible for faculty to track which students participated. Information regarding participation or non-participation was not available to instructors nor was individual responses to assessments. Investigators participating in this research had completed training in the protection of human participants including vulnerable populations.

Chapter II: Manuscript One

Integrative Review: Virtual Disaster Training

There were 99 major disaster declarations in the United States (U.S.) for the period of January to December, 2011 (Federal Emergency Management Agency [FEMA], 2011). In the past decade, the U.S. has suffered numerous devastating disasters including those of man-made and natural origins. Examples of these tragedies include the events of 9/11, hurricane Katrina, wild fires in California and recently hurricane Irene in the northeast (FEMA, 2010; FEMA, 2011).

A critical component of disaster preparedness is the training of the healthcare workforce (Joint Commission, 2006). Yet, there are continuing gaps in the education of healthcare workers in preparing for disaster response (Chapman & Arbon, 2008; Slepiski & Littleton-Kerney, 2010). The lack of disaster training opportunities is one challenge to preparedness. Live exercises are expensive and difficult to organize, but virtual environments may offer an accessible and economic tool to meet training needs (Heinrichs, Youngblood, Harter, Kusumoto & Dev, 2010). The evolution of telecommunication technologies, web-services and software engineering has opened the virtual world with synthetic representations of reality that can help provide realistic training exercises (Chen, Rebooledo-Mendez, Liarokapis, de Freitas, & Parker, 2008; Hansen, 2008; Roy, Sticha, Kraus & Olsen, 2006).

Immersive virtual reality simulation (VRS) is defined as a variety of computer-generated and synthetic experiences with an advanced interface within a human-machine simulation system (Beroggi, Waisel & Wallace, 1995). Chen, Rebooledo-Mendez, Liarokapis, de Freitas, and Parker (2008) describe virtual simulation as the use of shared space, graphic user interface, VRS allows the use of 3-D environments and computer interface to allow participants to interact within a virtual environment (Bergeron, 2008). There is a growing body of evidence that VRS can be used in disaster education and training. A few current examples of virtual simulation use

in disaster training include the Center for Disease Control's (CDC) recent implementation of virtual reality training for Deployment Safety and Resilience Team members within an immersive environment to prepare for disasters (Klomp, Sitlanick & Reissman, 2011). The Incident Command Training tools is a virtual reality training tool based upon the U.S. department of Homeland Security's Incident Management System (Barerra, 2008).

Purpose/Method

Due to the growing use of VRS in disaster education, greater understanding of the use of VRS and its effectiveness in disaster training of health care workers is needed. No existing review of the literature is found examining the use of VRS in the training of healthcare workers for disaster response. The purpose of this integrative review is to examine the state of the scientific evidence of the efficacy of VRS training in disaster training of healthcare workers. More specifically, this paper will answer the question: What is the state of the science related to the use of VRS training in disaster training for healthcare workers? The five-stage process described by Whittemore and Knalf (2005) was followed as the methodologic strategy for the integrative review. These stages include: identification of the problem and purposes, a defined search strategy (method), evaluation and analysis of data and the presentation of findings (Whittemore&Knalf, 2005).

Results

A search of diverse data bases was performed. These data bases include PubMed, the Cumulative Index of Nursing and Allied Healthcare Literature (CINAHL), Education Resources Information Center (ERIC), Academic Search Complete, Computer Source, and Computer/Applied Science. The inclusion of these diverse databases decreased the possibility of missing relevant literature. Search terms included: *virtual reality*, *virtual simulation*, *3-D*

immersion, serious game, serious gaming combined with either the search term *disaster* or *mass casualty incident*. There were 202 results for these searches. An additional five articles were obtained using the ancestry approach of examining references of relevant research reports (Cooper, 1998). Duplicate articles were removed. Articles were screened with the goal of finding articles that focused specifically on the use of VRS for the purposes of disaster training of healthcare professionals. All abstracts were reviewed for the following inclusion criteria: written in English, peer-reviewed literature and published during the time period of 2005-2011. An exclusion criterion was the use of virtual simulation for modeling the effects of disaster because these articles were not used for immersive training purposes.

The process used to obtain the final sample included three steps. Step one was the review of the abstracts for articles believed to meet the inclusion criteria. In step two, the full articles were printed from those identified articles (n=59). Finally, each printed article was read in its entirety for inclusion and exclusion criteria. Many of the articles were informational related to specific product development and implementation. These articles were excluded as they did not inform on the scientific state of immersive virtual reality disaster training. Twelve research articles were selected for inclusion in the review (Table 4).

Discussion

The articles were evaluated and compiled into a data matrix which included the following information: expertise of research team, methodology including sampling, setting, design and instruments, results, findings assessment of rigor and limitations. The sources were evaluated for authenticity, methodological quality, information value and representativeness (Kirkevold, 1997). A ten point system was used to evaluate the sources. No article was deleted due to a

lower score, instead those sources with higher scores served as the predominant informant, while those with lower scores were used in a more supportive role.

The findings of the studies were reviewed and analyzed. Three major themes were identified. These themes included: descriptions of the participant's experience in the virtual environment, learning results of participation in the VRS and an exploration of how knowledge construction occurs in the virtual environment. The greatest number of sources measured learning post experience, with a slightly lower number describing the virtual reality experience. Only one article sought to describe how knowledge was developed in the virtual environment.

Participant Experience

The following are studies that investigate the use of VRS and participant experience. Heinrichs, Youngblood, Harter and Dev (2008) evaluated participant VRS experiences in two scenarios using Likert-type questionnaires and focus groups with thirteen volunteer subjects and thirty volunteer subjects. In both scenarios the authors found a majority of participants felt immersed and found an increase in confidence following participation in VRS. Also using a Likert-type scale Kizakevich et al. (2007) found participants' feedback was overwhelmingly favorable examining realism, navigation, content, responsiveness and simulation learning content. Heinrichs, Youngblood, Harter, Kusumoto and Dev (2010) report that participants felt immersed in a VRS emergency department and that VRS was useful for learning teamwork and clinical skills. Vincent, Sherstyuk, Burgess, and Connolly (2008) and Wilkerson et al. (2008) reported that participants gave high evaluation scores to VRS training. The participants in these studies represented a diverse group of healthcare workers. The results of the studies were positive for the VRS experience with the majority of participants having reported feeling immersed in a realistic experience. In a study by Haferkamp, Kraemer, Linehan and Schembri

(2011) participants found that VRS was useful in training, but rated the simulation as far from reality, the authors identified the use of asynchronous chat as a barrier to participation in the VRS.

Limitations of the studies include the use of convenience samples and some studies lacking randomization of subjects. Overall the sample sizes were small ($n = 10-31$). The participant experiences were described using focus groups, Likert-type questionnaires and post-experience interviews. Little information is provided regarding reliability and validity of questionnaires or coding of qualitative data from focus groups or interviews.

Participant Learning

The following are examples of the articles that investigate participant learning in VRS. Bergeron (2008) administered pre/post and six-week tests to measure knowledge acquisition in VRS participants and traditional methods participants and found significantly greater learning in both groups ($n = 89$), but at six weeks the VRS group had significantly higher learning retention than the traditional group. Also using a pre/posttest design Van der Spek, Wouers, and Van Ostedendorp (2010) reported significantly improved post conceptual knowledge following a VRS experience ($n = 10$). Knight, Carley, Tregunna, Smithies, deFreitas, Dunwell and Machway-Jones (2010) found that triage tagging accuracy and triage step accuracy was significantly higher in a VRS training group than the group trained using a card sort exercise with no difference in time to triage ($n = 91$). Vincent et al. (2008), found improvement in triage scores, speed and self-efficacy after fully immersive VRS.

Heinrich et al. (2008) rated Emergency Medicine Crisis Management using a rating scale for behavioral performance in a VRS group and a Human Patient Simulator group. No significant differences in the scores were found between the groups. Andreatta, et al. (2008)

compared a VRS experience versus a live drill in assessing triage knowledge and found that there were no significant differences in triage performance between the two groups, but those who participated in the live drill had higher scores on the post test.

Measurement of the psychomotor skill of triage was a focus of more than one study; participant scores in accuracy and efficiency of triage were significantly higher in virtual simulation learners. Those studies which measured cognitive knowledge acquisition most often measured using pre/posttest. In each of the studies, concepts were measured with different tools. Although most used pre/post testing, little information is given related to the development, validity and reliability of most of these tools.

Knowledge Construction

Different theories exist regarding the construction, storage and recall of information, examinations of how VRS promotes and supports learning and retention needs to be examined. Only one article discussed how knowledge is constructed during participation in the VRS simulation. Van der Spek et al. (2010) used Pathfinder, a method measuring word pairs for mental model elicitation, to evaluate learner mental model structure pre and post VRS completion. The study found no change in mental model construction post VRS.

Conclusions

Disasters occur at a rate of approximately two per week in the United States (FEMA, 2011). A well trained healthcare workforce is needed to respond to these disasters. Current levels of training are not sufficient to prepare the workers. Cost restraints and logistic constraints make live simulation difficult, yet are critical in educating responders. VRS offers a potentially cost effective and efficient viable alternative. There are too few studies investigating the efficacy of virtual simulation and disaster training. Larger studies with n=100 or more, with

reliable and valid tools need to be performed with more detailed and rigorous interventions and measurement of long-term retention (12 or more months). There is a need to investigate the self-efficacy to act in different types of disasters, and behavioral determinations such as performance in triage, decontamination, and transport of victims need to be rigorously assessed.

VRS is experientially reported to help learners achieve learning outcomes (Andreatta et al., 2010; Bergeron, 2008; Knight et al., 2010; Van der Spek et al., 2010; Vincent, 2008). Participants' self-report that these environments are realistic and not difficult to use (Heinrichs et al., 2008; Heirich et al., 2010; Wilkerson, et al., 2008). Qualitative studies should be conducted which continue to describe the experience of those following VRS. Specific questions need to address how participants would describe the experience of virtual disaster training including immersiveness, reality, and the ability to navigate within the environment. The current studies involve a wide range of delivery systems including total immersion in a cave automatic virtual environment to simple mouse and monitor interaction (Wilkerson et al., 2008; Andreatta et al., 2010). All of these studies use a different method to deliver the VRS. Further research is needed to discover which of the variety of methods available for VRS are most efficient and effective in delivering content and providing realistic experiences for learners. Additional questions which need to be considered include: What type of virtual reality systems are most cost effective, portable, yet produce desired learning outcomes? What content is best taught with virtual simulation? A large number of these studies focused on triage, are there other circumstances such as decontamination and patient transport that are just as appropriate?

Finally, there is some limited quantitative data which supports the use of VRS to achieve sustained learning outcomes (Bergeron, 2008). Further studies are needed which explore the relationship of virtual learning with the acquisition and retention of learning of disaster training

concepts. What pedagogical programs and learning theories are supported by virtual simulation? How are learning and retention affected by participation in virtual disaster environments? How do feelings of immersion, presence, and view point effect learning and retention? Is autonomous learning or collaborative learning in the virtual reality environment superior? Virtual simulation is a new learning strategy; a body of evidence is needed to support the use of this modality in delivery disaster education.

Table 4: Article Summaries				
1 st Author/year	Purpose	Design /Subjects	Method	Findings
Andreatta, P.(2010)	Compare the relative impact of 2 simulation-based methods for training emergency medicine residents in disaster triage.	Two group Quasi experimental Convenience sample of 15 post-graduate residents who were randomly assigned to two groups	Each group received triage training either through VRS or live disaster drill. The independent variable=group assignment. Dependent variables=pretest score, triage score, triage rating and posttest score. Reliability of the test was not reported.	Groups had equivalent knowledge prior to training. VRS group had slightly better scores on actual triage performance. Triage scores were slightly higher for those in the live drill. No inferential statistics due to small sample size
Bergeron, B. P. (2008)	The authors designed and evaluated two serious games: The Radiation Hazards Assessment Challenge Game and The Nuclear Event Triage Game.	Experimental design using a convenience sample of 89 subjects (40 subjects in each group)	Control group received traditional didactic training and the experimental group received an intelligent tutoring system and participated in two serious games. Independent variable=training Dependent variable=scores pretest/posttest and a six-week posttest. Reliability of the test was not reported.	Tests scores from the posttest administered immediately post experience and in 6 weeks were significantly higher for the virtual simulation group than those from the control group $p<0.01$.
Haferkamp, N. (2011)	Evaluate a serious game which enables its users to	Descriptive mixed methods Convenience sample of 10	After completing a VRS, with asynchronous text chat, participants completed a debriefing	Crisis managers outperformed students in both trials. Students

	train soft skills in a virtual environment under safe conditions.	crisis managers 10 students 2 trials conducted (n=10)	session and a short questionnaire (Likert scale) to evaluate the effectiveness of the game in training social skills. They were also asked to evaluate: social skills training in the virtual experience (Likert scale), emotions experienced (Likert scale) and evaluate the game itself (Likert scale).	reported higher levels of stress and frustration. Both groups felt the VRS was useful in training, but rated the simulation as far from reality. Crisis managers preferred a more realistic simulation of disaster; the student sample focused more on the game play itself and achieving cooperation. The asynchronous chat was a limitation.
Heinrichs, W. L. (2010)	Determine whether a Virtual Emergency Department (VED) is an effective clinical environment for training ED physicians and nurses for MCI's	Descriptive mixed methods 10 physicians and 12 Registered Nurses	Participants received 30 minutes computer training and then participated as avatars within a virtual emergency room simulation. Participants completed entry questionnaire, exit questionnaire and focus groups were conducted.	2/3 reported feeling immersed. Training improved confidence in responding to events which was attributed to participation in the virtual environment. 95% thought the scenarios were useful in team training. 82% thought the VRS

				was useful in learning clinical skills management.
Heinrichs, W. L. (2008)	<p>Explore the feasibility of using 3D virtual world technologies for training and assessment of health care teams working in high-stress critical care areas such as emergency departments.</p> <p>-Create and evaluate online multiplayer scenarios</p>	<p>Descriptive study with post experience survey.</p> <p>13 volunteer subjects who were not gamers and reporting to have no MCI training.</p>	<p>Three virtual world studies are presented for team raining and assessment in acute-care medicine: One study, identified as a pilot study, was not included in the review.</p> <p>Participants in the first scenario evaluated their experiences following with Likert- type survey and had their performance evaluated using pre/post test cases. In the other scenario evaluated their experience by Likert type questionnaire.</p>	<p>In the first scenarios both groups demonstrated increased learning on pre/post case scenarios. There were no significant differences between the groups.</p> <p>Participants felt immersed and able to suspend disbelief. In the second scenario a majority (M-3.47) felt immersed and though that the session increased their confidence (compared with 2.00 prior to training). The simulation exercise would be useful for learning teamwork (M.3.77) as well as for learning clinical skills (3.15).</p>
Kizakevich	Evaluate a blended	Descriptive study with a	Participants evaluated the curriculum with a	Participant evaluation was

P.N. (2007)	didactic and virtual simulation-based curriculum for triage training.	convenience sample of 31 Iraqi physicians	questionnaire using Likert-type scale for qualitative measure of the presentation and simulation.	overwhelming favorable. Including realism, navigation, content, responsiveness and simulation learning content.
Knight, J. F. (2010)	Evaluate the effectiveness of a serious game in teaching of major incident triage by comparing it with traditional training methods	Quasi experimental with a convenience sample of 91 attendees of a Major Incident Medical Management and Support Course	Subjects were randomized into two groups 44 subjects were practiced triage using a card sort exercise, 47 participants used a virtual reality triage experience. Following the training each participant undertook an evaluation exercise triaging eight causalities in a simulated live exercise. Performance was assessed for correct triage category based upon victim injury, use of correct procedure, and time to triage. Assessment was performed by individual evaluator and confirmed by videotaping.	Tagging accuracy and step accuracy (in those who tagged correctly) was significantly higher in the virtual simulation group; there was no difference in time to triage between the two groups
van der Spek, E. D., (2010)	Develop a set of guidelines from empirical experiments that enhance the development	Descriptive study 10 emergency physician	Participant's pre-test posttest design. Pre and post participation subjects were evaluated to measure knowledge acquisition. Pathfinder, a method measuring word pairs for mental model	Scores were positive on the engagement scale. Post conceptual knowledge measured pre and posttest was significantly

	of serious games.		elicitation was completed along with conceptual knowledge questionnaire. Participants also completed an engagement questionnaire.	improved after training. No change in mental model structuring was found using the pathfinder method of mental model elicitation.
Vincent, D. S. (2008)	To measure knowledge acquisition of triage skills following participation in 3 virtual reality scenarios which include five simulated patients	Descriptive study 24 medical students (four students were excluded due to previous triage training) n=20	Participants participated in three separate virtual reality scenarios that included the triage of five patients. 3 outcomes measured were triage score, intervention score and time to triage for each scenario. Subjects completed a learner satisfaction and self-efficacy questionnaire of VRS experience.	All self-efficacy questions showed a statistically significant increase in scores over time. Triage and intervention scores improved significantly from Scenario A to B, but not from B to C. The VRS training evaluation scores were high.
Wilkerson, W. (2008)	This study explores the utility of immersive VRS for training first responders in a terrorism disaster scenario.	Descriptive study 12 paramedics	Participation in VRS using cave automatic virtual environment and high fidelity human patient simulation. Assessed for author defined critical actions using direct observation and video-taped recordings. Participants were interviewed post experience.	Learner feedback and expert performance review suggest that VRS has the potential to be a powerful tool to train first responders for high-acuity, low frequency events.

Chapter III: Manuscript Two

Effects of Disaster Training With and Without Virtual Reality Simulation

In the first half of 2011, there were 108 natural disasters worldwide, resulting in the deaths of over 23 thousand people. Nearly 44 million others have been affected with more than 253 billion United States (U.S.) dollars of economic damages (Centre for Research on the Epidemiology of Disasters, 2011). Given the prevalence of disasters there is an urgent need to improve the education of healthcare workers preparing for disaster response (Chapman & Arbon, 2008; Slepiski & Littleton-Kerney, 2010). One challenge to preparedness is a lack of disaster training opportunities. It is expensive, labor intensive and difficult to conduct live exercises, but virtual reality simulation (VRS) may offer an accessible and cost-effective alternative to meet training needs (Heinrichs, Youngblood, Harter, Kusumoto & Dev, 2010). The continued development of technology, web-services and software engineering has expanded the opportunity to develop VRS to practice disaster response. (Chen, Rebooledo-Mendez, Liarokapis, de Freitas, & Parker, 2008; Hansen, 2008; Roy, Sticha, Kraus & Olsen, 2006).

VRS uses 3-D environments and computer interface to allow participants to interact within a virtual environment (Bergeron, 2008). Moreover, VRS is increasingly being used as a method to educate health care workers to respond to disasters. A few current examples of virtual simulation use in disaster training include: the Center for Disease Control and Prevention's (CDC) recent implementation of virtual reality training for Deployment Safety and Resilience (Klomp, Spitalnick & Reissman, 2011) and the Incident Command Training virtual reality training tools based upon the U.S. Department of Homeland Security's Incident Management System (Barrera, 2008).

Purpose

The purpose of this innovative study was to examine the effectiveness of virtual reality disaster simulation in fostering knowledge acquisition and retention of disaster training in nursing students.

Two research questions were considered:

1. Are there differences in knowledge of disaster response between participants who receive Web-based disaster training compared to those who receive Web based training and a virtual disaster simulation experience?
2. Are there differences in retention of knowledge of disaster response between participants who receive Web based disaster training compared to those who receive Web based training and a virtual simulation experience?

It was hypothesized that participants who received Web-based disaster education augmented with a VRS experience would have increased learning and learning retention of disaster response strategies.

Review of the Literature

In reviewing current scientific literature related to VRS and disaster training three major themes were identified. These themes included: (1) descriptions of the participant's experience in the virtual environment, (2) learning results of participation in the simulation, and an (3) exploration of how knowledge construction occurs in the virtual environment.

1. Participant experience

Heinrichs, Youngblood, Harter and Dev (2008) and Kizakevich et al. (2007) evaluated participant VRS experiences in disaster training using ordinal response questionnaires. The authors found a majority felt immersed and reported an increase in confidence following

participation in the simulation. Physicians and nurses in a VRS, caring for disaster victims in an emergency department, felt VRS was useful for learning teamwork and clinical skills (Heinrichs, et al., 2010). Vincent, Sherstyuk, Burgess, and Connolly (2008) and Wilkerson, Avstreich, Gruppen, Beier and Woolliscroft (2008) reported that physicians and paramedics gave high evaluation scores to VRS disaster training. However, these studies were limited by the use of convenience and small samples sizes. Minimal information is provided regarding reliability and validity of questionnaires or coding of qualitative data from focus groups or interviews.

2. Participant Learning

To evaluate knowledge acquisition following VRS, Bergeron (2008) administered pre/post and six-week tests to two groups of nuclear first responders. 1) VRS participants and 2) traditional methods participants and found significantly greater learning retention in the VRS group at six weeks (n = 89). Knight, Carley, Tregunna, Smithies, de Freitas, Dunwell and Machway-Jones (2010) further found that triage tagging accuracy and triage step accuracy was significantly higher in a VRS training group compared to a group trained using a card sort exercise. Study participants were attendees at a Major Incident Management Support course. In this same study they found no difference in time to triage between the two groups (n = 91). Although most of the studies used pre/post testing; minimal information is available related to the development, validity and reliability of these tools.

3. Knowledge Construction

Van der Spek, Wouers and van Osterdendorp (2010) explored how learning was fostered in the VRS in a small pilot study involving paramedics and triage. The authors measured associated word pairs for mental model elicitation in forming conceptual models, to evaluate learner mental model structure pre and post VRS completion. The study found no change in

mental model construction post simulation, but the study was limited by size, use of convenience sample and the use of previously triage trained subjects.

As indicated by these limited research efforts, VRS reportedly provides a realistic environment for disaster training. In other studies, VRS demonstrated equal or improved learning outcomes immediately post training to traditional teaching methods. These positive outcomes of VRS may be explained by the learning theory of situated cognition.

Theoretical Framework

Situated learning theory supports the use of virtual simulations as a method of increasing learner's knowledge and retention (Bares, Zettlemoyer, & Lester, 1998; Brown, Collins & Duguid, 1989). This theory is based upon concepts of embodiment (cognition is dependent on the sensorimotor brain and body), embeddedness (cognition is fixed in context specific representations) and extension (cognitive systems exist in a physical and social environment) (Robbins & Aydede, 2009). The domain of learning is the culture in which acquired knowledge will be used. For example, the scalpel cannot be used appropriately without understanding the community or culture of the operating room. Meaningful learning will only take place if it is embedded in the culture of the situation. Educational technology, through virtual reality and interactive multimedia, is supported as an avenue to bring situated learning into the classroom. (Harley, 1993). According to Herrington and Oliver (1995), virtual simulations “provide a powerful acceptable vehicle for the critical characteristics of a traditional apprenticeship” (p.2).

Methods

Design

The current study was a longitudinal experimental design using two groups and repeated measures

Participants

An *a priori* power analysis was conducted using G*Power 3.1 (Faul, Erdfelder, Lang, Buchner, 2009) to determine the required sample size; for the purposes of feasibility a sample total of 32 (16 in each group) was preferred to achieve a minimum of 80% power assuming a small effect size, autocorrelation of .2, and $\alpha = .05$. Given the potential for attrition from the study, sample size was increased to a total desired sample of 40. Inclusion criteria were that participants be at least 18 years of age and able to participate in VRS. Exclusion criteria were previous extensive disaster training or paramedic certification.

Instrument

Competencies for the disaster course were based upon the criteria developed by the International Nursing Coalition for Mass Casualty Education (INCMCE) (2003). Items for the post assessment measured educational competencies for registered nurses responding to mass casualty incidents (INCME, 2003). The formative assessment tool used in the study consisted of 20, criterion-referenced, multiple-choice questions. In addition, the assessment used in the study was developed from an existing author-developed exam. Previous administration of the assessment reliability was measured using KR 20 and was found to be an acceptable $r = .72$ (Miller, Linn & Gronlund, 2009).

Validity. The assessment, in its existing form, was assessed for validity by a panel of three disaster experts and three education experts. Disaster experts were asked to evaluate each

question to assess content validity. For each question the reviewer was given the question and the competency it measured. Reviewers were asked to judge the following criteria derived from Miller, Linn and Gronlund (2009): item congruence, relevance of item to content domain, accuracy of the assessment item, inaccuracy and suitability of distracters.

Education experts reviewed the questions using items derived from Burton, Sudweeks, Merrill, and Wood (1991). Item analysis from previous administrations of the assessment was provided to reviewers including the item difficulty, discrimination and distractor analysis.

Examples of evaluation questions include: Has the item been constructed to assess a single written objective? Was the stem clear without irrelevant material and stated in a positive form? Were alternatives homogenous in content, free from clues to the correct response, clear and consistent with appropriate grammar, punctuation and spelling?

Reliability. After completion of the post assessment by student participants, two methods of reliability were assessed including a Kuder Richardson coefficient of reliability (KR20) (Kuder & Richardson, 1937) and calculation of the test/retest reliability coefficient.

Procedure

Within this study, the type of disaster training was the independent variable; learning and retention were the dependent variables. The participants were randomly assigned to intervention group (web-based teaching method only) or standard care group (web-based teaching with virtual simulation group) for disaster training. All nursing students in the capstone courses and pediatrics courses were invited to participate in the disaster training study via announcements and email. Students who chose not to participate in the research study were directed toward “Traditional” modules. Participants consented to participate in the study by selecting the

“Simulation Study” modules and were randomized into two groups using the learning management system’s random team generator.

The control group completed the web-based disaster training modules alone and the treatment group completed the web-based disaster modules and a virtual disaster simulation. Prior to participating in the modules both groups of participants completed a pre-assessment of twenty multiple choice questions. After training, both groups of participants again completed the twenty question multiple-choice assessment. Two-months post disaster training, email reminders were sent to all participants to participate in the final multiple-choice assessment.

The control group completed only the web-based disaster training modules. After completion of web-based modules, the treatment group was prompted to access the VRS. There was a short orientation to the simulation environment and then students participated in a VRS experience reinforcing the concepts of disaster training. Using a computer with internet capability, a mouse and a keyboard, learners accessed two virtual disaster scenarios. Each scenario lasted approximately ten minutes. The participant was able to assess, triage and provide first aid to victims of radioactive and explosive events. The tutorials offered both summative and cumulative performance feedback during and after each scenario and reinforced the concepts taught in the disaster course. After completing the simulation, participants completed the online post-assessment. The two- month assessment was open for completion for seven days. After completion of all three assessments, within the two-month time frame, all participants had the option of receiving a Starbucks gift card as compensation for their time. Table 2 summarizes the procedure:

Table 2: Procedure			
	Pre Assessment	Treatment/ Post Assessment	2 months Assessment
Random Assignment	Assessment ₁	Assessment ₂	Assessment ₃
	Assessment ₁	Assessment ₂	Assessment ₃

Web-based education.

The first component of the educational intervention was the web-based learning modules. There were five sets of modules developed from the learning objectives recommended by the International Coalition Nursing for Education of Mass Casualty Incidents (2003). Modules focused on creating a greater understanding of clinical issues pertaining to direct nursing care of victims. Topics included concepts of detection, personal protection and immediate care for those impacted by disaster. All of the modules consisted of textual narration and embedded active learning strategies such as practice questions, labeling activities and scenarios.

Virtual simulation intervention. A virtual simulation was developed to reinforce the web-based learning presented in the online modules. The scenarios took approximately thirty minutes to complete. The simulation content was developed by the study author and reviewed by three disaster experts for authenticity of activity, correctness of modeling processes, and the appropriateness of roles and perspectives. Three education experts assessed the simulations' ability to: a) support construction of knowledge; b) effectiveness of coaching and scaffolding; c) the scenario's ability to promote reflection and abstraction; and, d) integration of assessment of the learning tasks (Herrington & Oliver, 1995). After the simulation script had been reviewed and revised, the simulation was articulated into the 3-D environment using the Second Life platform (Second Life, 2011). A tutorial was adapted for use with the module to familiarize the participants with the virtual environment.

Human Subject Protection

Approval was obtained from the institutional review board of the University and community college. Participation was voluntary and information regarding participation or non-participation was not shared with instructors nor were responses to assessments.

Findings

Participants were recruited from second year Associate Degree nursing students enrolled at a community college. Students enrolled in the program ranged in age from 18-57 years of age. The student population is 73% White, 18% African American and 7% Asian and 2% Hispanic. The majority of the students were female 91% and 9% are male (M. Miller, personal communication, May 5, 2010). Seventy five students were invited to participate in the study, of these 54 (total response rate of 72%) responded that they would participate in the study. Of those agreeing to participate, 47 participants completed the pre-assessment, post assessment and 41 participants (13% attrition) completed all three assessments. Within the sample completing the first two assessments there were 4 men and 43 women. Ages of participants completing all three assessments were as follows: 10 were 18-25 years old, 10 were 26-33 years old, 13 were 34-41 years old, 7 were 42-49 years old and 1 student was 50 and over.

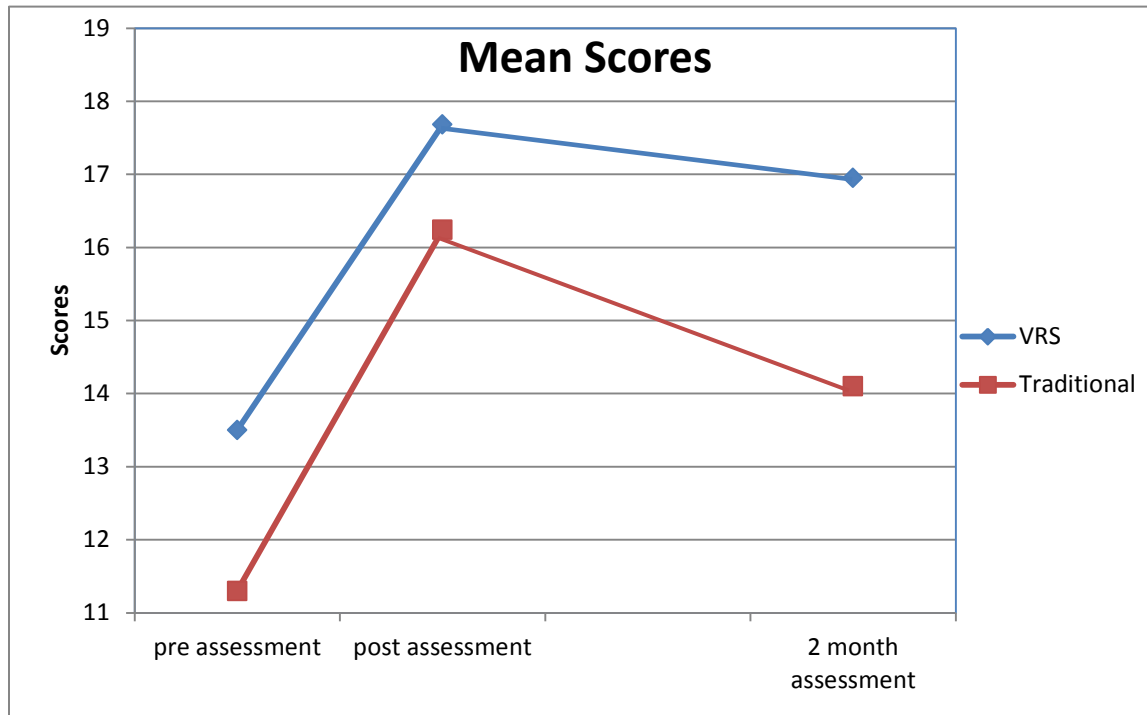
To assess score consistency or stability of the assessment, a Pearson's product moment correlation coefficient was computed to assess test-retest reliability. The results demonstrated score consistency and stability with $r = .73$ (Murphy & Davidshofer, 2005; Leech, Barrett & Morgan, 2008). The immediate post-assessment mean was 16.91, and standard deviation was 2.165. The two month administration, mean was 15.56, and the standard deviation was 2.618. To assess the internal consistency of the items KR20 was also computed. A value of $r = .62$, was obtained which is acceptable reliability for a criterion referenced assessment, especially due to

the homogeneity of the population of second-year nursing students and the small number of questions (McGahee and Ball, 2009). According to Oermann and Gaberson (2009), a reliability coefficient of .60-.85 is desirable for nursing assessments.

Item analysis was conducted on the post assessment participant data. Three items were answered by all participants correctly; these items were identified prior to administration as master items (high priority) and it was anticipated they would be answered correctly (Morrison, Nibert & Flick 2006). All other items scores were positive; ranges on the point biserial correlation coefficients of .21-.68 was interpreted as good to excellent (Morrison, Nibert & Flick, 2006). Item difficulty ranged from 31% to 100%. Distractor analysis was performed on response frequencies and overall demonstrated good dispersion of responses among distractors.

Histograms of variables were plotted and examined. The data were found to be non-normally distributed so advanced statistical methods were required. To address the research questions and to assess the overall effect of the VRS, the results of the assessment scores were analyzed by SPSS software using the generalized linear model, implementing generalized estimating equations. Generalized linear models extend linear regression models to accommodate both non-normal response distributions and transformation of linearity (Diggle, Heagerty, Liang, & Zeger, 2002). A Tweedie distribution was used in the model which accommodated the mixed distribution pattern of the data. A log-link function was used to account for skew in the dependent variable. The GEE was used to account for clustering observed in the longitudinal data (McCullagh & Nelder, 1989). Model fit was confirmed by comparing the using the Quasi-likelihood information criterion (QIC) of the full model to the QIC of an intercept –only model. A critical alpha level of .05 was used to demonstrate statistical significance.

The omnibus test of the overall model was calculated using a Wald statistic and was highly significant ($p < .0001$) indicating that there were significant differences between the VRS (treatment) and non-simulation (control) groups. Six of the two-month post assessment scores were missing due to subject attrition. Therefore, missing data were predicted using a regression equation with pre- and post-assessment data to predict the missing two-month scores. No substantive differences were found in the statistical significance of the model when using the imputed data compared to the model created from the original data set with missing data. Overall, the main effect of the virtual simulation was strongly significant ($p < .0001$). Although the initial independent t-test of the pre-assessment demonstrated that the two groups differed significantly, the use of GEE controlled for these differences when the research question was answered. Both groups showed similar rate of improvement of scores following the teaching intervention in the first post assessment. The significant differences can be seen in the scores at two-months post intervention (see Table 5 and Table 6). The virtual simulation effect demonstrated significant stability over time. The non-simulation (control) group showed significant decay in scores.

Table 5: Scores**Table 6: Assessment Results**

Assessment	Number of Participants	Mean	Standard Deviation	Standard Error
Pre-assessment: Both groups	47	12.13	3.374	2.374
Pre-assessment: Control group	25	11.30	2.021	.404
Pre-assessment: Simulation group	22	13.5	2.516	.536
Post-assessment: Both groups	47	16.91	2.165	.316
Post-assessment: Control group	25	16.24	2.134	.436
Post-assessment: Simulation group	22	17.68	1.729	.369
2-month: Both groups	41	15.56	2.618	.409
2-month: Control group	20	14.10	2.490	.557
2-month: Simulation group	21	16.95	1.910	.417

Within and Between Subject Differences

Individual scores between participants were compared using independent sample t-tests. Significant differences were found between the two pre-assessment groups, $p = .023$. In addition, scores between the immediate post-assessment groups differed significantly ($p = .021$) and group differences on the 2-month assessment were significant ($p < .0001$). The VRS group scored higher in each instance. The within group effects of the two groups were explored using paired t-tests. There were significant differences between the pre and post assessments ($p < 0.001$), the post assessment and 2-month assessments ($p < .0001$). Paired samples correlations indicated strong correlation between posttest test scores and two-month scores ($p < .0001$).

Discussion

In this preliminary study, the VRS had a strong positive effect on retention of disaster training. When looking at the immediate post assessment and two month post data, a significant difference was found in the stability of the assessment scores in the VRS group over time. The first research question: *Are there differences in knowledge of disaster response when comparing participants who receive Web-based disaster training to those who receive Web-based training and a virtual disaster simulation experience?* The VRS group demonstrated higher scores on the immediate post assessment; but the group differences were not statistically significant when the differences in the pre-test were accounted for. In answering the second research question: *Are there differences in retention of knowledge of disaster response when comparing participants who receive Web-based disaster training to those who receive Web based training and a virtual simulation experience?* The VRS group demonstrated significantly higher scores on the two-month post assessment and demonstrated improved retention ($p < .0001$).

These results support those of Bergeron (2008) who found retention scores were stable for the VRS groups with decay in scores for the control group six weeks post training. In addition, participant experiences with the VRS were similar to other studies in that participants in reported that VRS is a realistic and positive learning experience (Heinrichs et al., 2008; Kizakevich et al., 2007; Heinrichs et al., 2010; Vincent et al., 2008).

Limitations of the study include use of convenience sampling, sample size and the length and number of assessments of the study. Only cognitive testing was used to measure learning and retention, testing within the psychomotor and affective domains is needed. The VRS group supplied course evaluations of the VRS experience. Eighty percent of participants gave positive comments about participation in the VRS. Positive comments included multiple references to applying information in a visual way not available in a passive module setting, realistic experiences, and a better understanding of zones of triage. Unfortunately, some participants gave feedback that they had difficulty navigating the VRS. Reasons given included the controls and operating of teleports within the VRS were difficult to maneuver. Only one of the participants provided negative feedback reporting that the VRS was not realistic.

During the VRS, participant progression through the scenarios was tracked. The tracking gave more evidence that the scenario was difficult to manipulate. VRS participants did not complete all aspects of the simulation uniformly. Twenty-four percent ($n = 6$) of the VRS participants completed fewer than half of the 15 stations within the VRS. Despite the failure to interact with all the patients in the triage scenarios, the VRS still significantly affected learning retention at two months.

Benefits of VRS include the ability to replicate actual buildings and areas into realistic scenarios. A wide variety of disaster situations can be modeled including both manmade and

natural disasters. Participants may repeat the scenarios at any time. Their performance can be tracked and evaluated throughout the scenario. In future studies the development of the VRS must offer the participant ease of navigation and strong feelings of embeddedness. The VRS in this study was from the focus of a single player view, while multi-player simulations allow for interaction between participants may strengthen the learning experience by improving extension (interaction between environment and others) within the VRS.

Conclusion

In this preliminary examination, VRS is an instructional method that reinforces learning and improves learning retention. The use of VRS in disaster training may improve accessibility and cost effectiveness as an alternative, or supplement, to live drills. Further study is necessary in the use of VRS in disaster training and an exploration of areas of learning where VRS may be an applicable pedagogy in nursing education. Larger studies involving more subjects and varied VRS delivery methods are essential. Studies are needed with more longitudinal data to explore the stability of the learning effect. All three domains of learning need to be examined when testing the effects of VRS. Evaluations of cognitive, affective and psychomotor responses to VRS are needed so that researchers can examine the translation knowledge of VRS content to live disaster situations. It is important to be able to demonstrate that cognitive knowledge transforms into the willingness and ability to perform well in disaster situations. Further improvements of VRS may improve the results of this study.

Chapter IV: Manuscript Three

Translation to Practice: Virtual Reality Training

The future of nursing in today's world requires an examination of how we educate and what content we impart to nurses (Benner, Sutphen, Leonard, Day, 2010). Just as clinical practice needs to be grounded in evidence, effective nursing education is dependent upon the development and use of andragogic and pedagogic evidence (Institute of Medicine, 2011). Educational research findings must be transformed into useable education strategies. The purpose of this paper is to provide an exemplar of the translation of virtual reality simulation (VRS) research findings into nursing education practice.

The Ace Star Model is a conceptual framework set forth to systematically put evidence-based practice processes into operation (Stevens, 2004). The model identifies five key stages to transform knowledge (i.e. research) into practice. The first stage is that of knowledge discovery. Using scientific inquiry, both new qualitative and quantitative knowledge is discovered. In stage two, evidence is summarized into a meaningful statement. The third stage results in the development of practice guidelines and recommendations. The fourth stage of the model includes the integration of the strategy into practice. In the final stage outcomes are evaluated (Stevens, 2004).

Background and Significance

Disasters occur at a rate of greater than one per week in the United States (Federal Emergency Management Agency, 2011). There is an ongoing need to improve the education of healthcare workers training for disaster response (Chapman & Arbon, 2008; Slepiski & Littleton-Kerney, 2010). Preparation for disasters may be hindered by limited access to disaster training opportunities; disaster drills are costly and difficult to coordinate. An alternative method to train

responders is virtual reality simulation (VRS) (Heinrichs, Youngblood, Harter, Kusumoto & Dev, 2010). VRS is defined as a method in which a computer simulates a three-dimensional physical environment using visual and auditory stimuli with and within which an individual can interact with the created surroundings (Encarta, para 1, 2009).

Point 1: Discovery

In a longitudinal study using an experimental design the effects of disaster training with and without VRS were explored. The subjects of the study, second year, Associate Degree, nursing students participated in disaster training using web-based models. The control group used the web-based modules alone and the treatment group completed the web-based modules and a VRS to reinforce content. Learning and retention were measured using a 20 question multiple choice test. Content validity of the tool was accomplished through review by both disaster and education experts. Reliability of the assessment was determined by test-retest ($r=.72$). Three measurement points were assessed pre, post and two months following training.

The results of the assessments were analyzed using the generalized linear model and general estimating equations. The overall effect of the VRS was found to be strongly significant ($p<.0001$). Although the two groups did not differ significantly on the immediate posttest, differences between the groups at two months were significant ($p<.0001$). Scores within the VRS group were significantly higher indicating greater retention of disaster training content. Furthermore, in evaluating the VRS experience learners reported that the VRS enhanced learning by providing a realistic opportunity to practice skills.

Point 2: Evidence Summary

The VRS research evidence is synthesized into one meaningful statement: Preliminary results indicate that VRS provides a realistic environment for instruction which increases

retention of learned knowledge of disaster training. The work of Bergeron (2008) supports these findings, following disaster training and administration of pre/post and six-week tests to two groups (VRS participants and traditional methods participants) significantly greater learning retention was found in the VRS group at six weeks (n = 89).

Participant report of realism and immersion within the VRS were also confirmed by other studies. VRS has consistently been found to be a realistic and immersive environment for disaster training. Heinrichs, Youngblood, Harter and Dev (2008), Heinrichs, Youngblood, Harter, Kusumoto and Dev (2010) and Vincent, Sherstyuk, Burgess, and Connolly (2008) have all explored the use of VRS and disaster training. Using both quantitative and qualitative methods the studies report that participants consistently find VRS a genuine and convincing learning environment.

Point 3: Translation

In implementing a VRS, content, education and technology experts are needed. Consultation among these experts prior to and throughout development process is required for a successful VRS. Early discussions regarding the method of VRS are critical. Many systems are available for VRS delivery including a range of modalities from total immersion in special rooms to less immersive environments using monitor, keyboard and mouse (Strangman, & Hall, 2003). Points to consider when selecting the VRS system include: 1) The simulation needs to be built in a manner that facilitates embeddedness (cognition is fixed in content specific representations), extension (individuals exist in social and physical environments) and embodiment (cognition is linked to the sensorimotor brain and body) (Robbins & Aydede, 2009); 2) What is the depth and breadth of information that needs expressed (audio, visual, touch) (Steuer, 1992)? Inclusion of all three of these elements is optimal, but not always practical and effective simulations may

include only audio and visual components. 3) What element of immersion within the simulation is needed?

Content experts identify the domain of learning for the simulation. Appropriate measurable learning objectives are then developed. From the objectives the specific content of simulation is determined. A story board is created for scripting of the scenarios including: activities, challenges, redirection, narration and evaluation of performance which facilitate learning and retention of content (Van der Spek, Wouers, & Van Ostedendorp, 2010). As the VRS is designed, education experts ensure that the simulation 1) will support construction of knowledge 2) scaffold content to provide immediate availability of help, intentional assisting and expert modeling (Zhao & Orey, 1999) 3) provide coaching 4) promote reflection and abstraction and 5) integrate assessment of learning tasks (Herrington & Oliver, 1995). After the development of content and simulation scripting, the simulation is articulated into the virtual environment and pilot testing begins.

Point 4: Integration

Integration of VRS into disaster training poses some challenges. Creation of VRS is costly and requires specialized training to develop, but once produced these scenarios can be used repeatedly by many participants. Learners must also have access to appropriate technology to take part in the VRS and both educators and students must be trained in the use of the VRS. In exploring the extensive numbers of systems available for delivery of VRS questions need to be considered: What is the cost of the system and equipment needed to participate in the VRS? How expensive will the design and implementation be? What level of immersion is needed to accomplish learning objectives? Will participants benefit from social interaction within the VRS, should a single player or multiplayer system be used? What will be the perspective of the

learner, first person or third person? Schuurink and Toet (2010) found no difference in participant's affective appraisal of engagement in VRS in either first or third person, but found higher perceptions of environment in those participating in a third-person perspective.

Point 5: Evaluation

Although preliminary studies indicate that VRS is as an effective education modality in disaster training, it requires further investigation with larger samples. Given that most hospitals have mandatory annual staff training, knowledge retention studies spanning at least one year in length are highly recommended. In addition, research must be performed that examines whether the knowledge presented in VRS translated into actual performance behaviors in real disasters. Other aspects pertaining to VRS that need closer scrutiny are analysis of the efficiency, effectiveness, and cost of the various types of VRS delivery systems (e.g., CAVE total immersion, monitor-keyboard and mouse). Because VRS is an active learning strategy allowing students to “learn by doing” in a controlled environment, any learning environment real or imagined can be manufactured in a VRS. Plus, students are safe to explore and learn in a digital environment where repetition of experience can easily be accomplished. With the increased emphasis on digital media, social networks, and gaming as viable teaching strategies, it is imperative that nurse researchers perform targeted investigations to expand the body of evidence regarding these educational approaches.

Chapter V

Summary, Conclusions, and Recommendations

In this final chapter, a summary of the dissertation manuscripts is provided. Conclusions based on the results and discussions are presented. In addition, recommendations for translation to practice and future research trajectory are offered.

Summary

Disasters occur at the rate of almost two per week in the United States and a well-trained healthcare workforce is needed to respond to these crises (FEMA, 2011; Joint Commission, 2006). In a study of emergency nurses perceptions of preparedness, Considine and Mitchell (2009) found that nurses believed significant deficiencies existed in disaster training. Nurse leaders have further identified a need for disaster training of professional nurses (American Nurses Association, 2010). The International Nursing Coalition for Mass Casualty Education (INCMCE) (2003) calls for the education of all nurses in disaster preparedness and the addition of mass causality incident management in nursing school curricula.

The use of drills is seen as an integral component of disaster training (Joint Commission, 2006), but it is expensive, labor intensive and difficult to conduct live exercises. Virtual reality simulation (VRS) may offer a more accessible and cost-effective method to meet disaster training needs (Heinrichs, Youngblood, Harter, Kusumoto & Dev, 2010). VRS, in disaster training, uses 3-D environments and computer interfaces to present disaster situations in an interactive virtual environment (Bergeron, 2008). Moreover, VRS is increasingly being used as a method to educate healthcare workers to respond to disasters.

Manuscript 1: Integrative Review

Virtual reality simulation as a possible method for delivery of disaster training has some support in the scientific literature. The first manuscript (Chapter Two) of the dissertation presents an integrative review of the literature which provides an in-depth assessment of the current state of the scientific evidence related to VRS and disaster training of healthcare workers. The review served to identify the gaps in the scientific evidence that currently exist and implications for further investigation. Using the five-stage process described by Whittemore and Knalf (2005) as the methodologic strategy, the integrative review identified three major themes within the literature.

As part of this integrative review, the first theme identified participants' descriptions of experiences in the virtual environment. Several studies suggest that VRS offers a realistic and positive learning environment including Heinrichs, Youngblood, Harter and Dev (2008), Heinrichs et al. (2010) Kizakevich et al. (2007) Vincent, Sherstyuk, Burgess, and Connolly (2008) and Wilkerson, Avstreich, Gruppen, Beier and Woolliscroft (2008) all evaluated healthcare worker's VRS experiences using disaster scenarios. Methods of assessment included questionnaires, interviews and focus groups. Results of these studies were overwhelmingly favorable. The majority of participants having reported feeling immersed in the VRS and described it as a realistic experience. Unfortunately, the reviewed studies had many limitations. For instance, several studies were limited by the use of convenience samples and some studies lacking randomization of subjects. Overall, the sample sizes were small ($n = 10-31$). Plus, little information was provided regarding reliability and validity of questionnaires or coding of qualitative data from focus groups or interviews.

The second theme was descriptions of the effect that VRS had on learning and retention in disaster training. The majority of these articles discussed learning outcomes following VRS disaster experiences. One example is Bergeron's (2008) study of nuclear response training participants. Knowledge acquisition was measured using pre/post and six-week tests following disaster training with either VRS or traditional methods. Scores on the immediate posttests were similar, but at six weeks the VRS group demonstrated significantly higher scores. Van der Spek, Wouers, and Van Ostedendorp (2010) studied paramedics using a VRS triage exercise and reported significantly improved post-conceptual knowledge following a VRS experience (n = 10). Andreatta, et al. (2008) compared a VRS experience versus a live drill in assessing triage knowledge and found that there were no significant differences in triage performance between the two groups, but those who participated in the live drill had higher scores on the post test. In each of these studies learning was measured with different tools; most often with pre/post cognitive testing, little information was given related to the development, validity and reliability of most of these tools. Cognitive testing was not the only method used to determine knowledge acquisition. Psychomotor triage skills were measured in more than one study. Accuracy and efficiency of triage were measured and found to be significantly higher in virtual simulation learners (Knight et al., 2010; Andreatta et al., 2008). In addition, Vincent et al. (2008) found improvement in triage scores, speed and self-efficacy after participants completed a fully immersive VRS.

The final theme focused on how knowledge construction occurred in the virtual environment. Van der Spek et al. (2010) used Pathfinder, a method measuring word pairs for mental model elicitation, to evaluate learner mental model structure pre- and post- VRS completion. The study investigated how VRS contributed to knowledge construction, storage

and recall. Post-conceptual knowledge measured both pre- and posttest was significantly improved after training, but the authors found no change in mental model structuring following VRS.

Gaps

The integrative review of the literature concluded that there are too few studies investigating the efficacy of virtual simulation and disaster training. Larger studies with n=100 (probability samples) or more, using reliable and valid tools need to be performed with detailed and rigorous interventions and measurement of long-term retention (12 or more months). It is essential researchers assess the self-efficacy to act in different types of disasters, and evaluate behavioral determinates such as performance in triage, decontamination, and transport of victims. Only one study provided limited quantitative data supporting the use of VRS to achieve sustained learning outcomes. Further studies are needed which explore the relationship of virtual learning and knowledge retention.

Manuscript Two: Description of Study Methodology and Findings

The Research Strategy

The current study proposal is presented in Chapter One of the dissertation. The purpose of this study was to examine the longitudinal effects of virtual reality simulation (VRS) on learning outcomes and learning retention of disaster training with Associate Degree nursing students. The specific aims of this proposal were to compare the effectiveness and learning retention of virtual reality simulation to traditional disaster teaching in the context of disaster training.

Research questions.

1. Are there differences in knowledge of disaster response when comparing participants who received Web-based disaster training and those who received Web-based training and a virtual disaster simulation experience?
2. Are there differences in retention of knowledge of disaster response when comparing participants who received Web-based disaster training and those who received Web-based training and a virtual simulation experience?

Research design.

The study employed a longitudinal experimental design using two groups and repeated measures. The participants were randomly assigned to either an intervention group (Web-based teaching method with VRS) or standard group (Web-based teaching only) for disaster training.

Methods.

Participants were a convenience sample of second year Associate Degree nursing students enrolled in a disaster course. The inclusion criteria were over 18 years of age and able to speak English, while the exclusion criteria were previous disaster training certification, paramedic certification or physical limitations preventing participation in virtual simulation. Consented subjects were randomized to two groups; one group completed Web-based modules alone. The other group completed both the Web-based modules and a virtually simulated disaster experience. Learning was measured using a 20 question multiple choice assessment pre/post and at two months following training. To address the research questions and to assess the overall effect of the VRS the results of the assessment scores were analyzed by SPSS software using the generalized linear model, implementing generalized estimating equations

(GEE). Independent and paired t-tests were used to examine the between and within participant differences.

Findings.

Participants were recruited from second year Associate Degree nursing students enrolled at a community college. Students enrolled in the program ranged in age from 18-57 years of age. The student population is 73% White, 18% African American and 7% Asian and 2% Hispanic. The majority of the students were female 91% and 9% are male (M. Miller, personal communication, May 5, 2010). Seventy five students were invited to participate in the study, of these 54 (total response rate of 72%) responded that they would participate in the study. Of those agreeing to participate, 47 participants completed the pre-assessment, post assessment and 41 participants (13% attrition) completed all three assessments. Within the sample completing the first two assessments, there were 4 men and 43 women. Ages of participants completing all three assessments were as follows: 10 were 18-25 years old, 10 were 26-33 years old, 13 were 34-41 years old, 7 were 42-49 years old and 1 student was 50 and over.

Stability of the assessment tool was evaluated using test-retest reliability of the disaster assessment scores. The re-test results demonstrated satisfactory score consistency and stability with $r = .73$. (Murphy & Davidshofer, 2005; Leech, Barrett & Morgan, 2008). To assess the internal consistency of the items Kuder Richardson (1934) KR20 was computed. A value of .62 was obtained which is acceptable reliability for a criterion referenced test, especially due to the homogeneity of the population of second year nursing students and the small number of questions (McGahee & Ball, 2009; Oermann & Gaberson, 2009).

Item analysis was also conducted on the post assessment participant data. With the exception of three mastery items (answered correctly by all participants), all item scores were in

the positive range, with point bi-serial correlation coefficients of .21-.68 which is interpreted as good to excellent (Morrison, Nibert & Flick, 2006). Item difficulty ranged from 31% to 100%. The distractor analysis of response frequencies demonstrated good overall dispersion of responses among distractors.

Histograms of variables were plotted and examined and the data were found to be non-normally distributed requiring the use of advanced statistical methods. The assessment scores were analyzed by SPSS software using the generalized linear model, implementing generalized estimating equations (GEE). Generalized linear models extend linear regression models to accommodate both non-normal response distributions and transformation of linearity (Diggle, Heagerty, Liang, & Zeger, 2002). The GEE was used to account for clustering observed in the longitudinal data (McCullagh & Nelder, 1989). Model fit was confirmed using the Quasi-likelihood information criterion (QIC) of the study model compared with an intercept only model. A critical alpha level of .05 was used to demonstrate statistical significance.

Using the Wald statistic, the omnibus test of the overall model was highly significant ($p < .0001$) indicating that there were highly significant differences in the VRS (treatment) and non-simulation (control) groups. Although the initial independent *t*-test of the pre-test demonstrated that the two groups differed, the use of generalized estimating equations controlled for these differences overall when the research question was answered. On the immediate post assessment, both groups showed similar improvement of scores. Significant differences were demonstrated in the two-month post-assessment scores. The virtual simulation effect demonstrated stability over time with significantly less decay in scores than the non-simulation group.

The first research question: *Are there differences in knowledge of disaster response when comparing participants who receive Web-based disaster training to those who receive Web-based training and a virtual disaster simulation experience?* The VRS group demonstrated significantly higher scores on the immediate post assessment; it is important to note that the VRS was also higher on the pre-test. In answering the second research question: *Are there differences in retention of knowledge of disaster response when comparing participants who receive Web-based disaster training to those who receive Web based training and a virtual simulation experience?* The VRS group demonstrated significantly higher scores on the two-month post assessment and demonstrated improved retention ($p < .0001$).

Bergeron (2008) demonstrated similar results, finding retention scores were stable for the VRS groups with decay in scores for the control group six weeks post training for nuclear event response. In addition, participant VRS experiences in the current study were similar to other study's with participant's finding that VRS is a realistic and positive learning experience (Heinrichs et al., 2008; Kizakevich et al., 2007; Heinrichs et al., 2010; Vincent et al., 2008).

The current study's VRS group supplied course evaluations of their VRS experience. Eighty percent of participants gave positive comments about participation in the VRS. Positive comments included multiple references to applying information in a visual and active way not available in a passive module setting, realistic experiences, and a better understanding of zones of triage.

Limitations

Limitations of this study include use of convenience sampling, sample size, number of assessments and the length of the study. The current study only looked at the use of cognitive testing as a means of assessing learning and retention. Psychomotor and affective domains were

not addressed. Unfortunately, some participants gave feedback that they had difficulty navigating the VRS. Reasons given included the controls and operating within the VRS was difficult to maneuver. Only one of the participants provided negative feedback reporting that the VRS was not realistic of a disaster situation.

Participant progression and activity was tracked within the scenarios. The tracking data supported comments that the scenario was difficult to manipulate. Twenty four percent ($n = 6$) of the VRS participants completed fewer than half of the 15 stations within the VRS. Despite the failure to interact with all the patients in the triage scenarios, the VRS still significantly affected learning retention at two months.

Conclusions

In the current study, VRS is an instructional method that reinforces learning and improves learning retention. The use of VRS in disaster training may improve accessibility and cost effectiveness as an alternative to live drills. Further study is necessary in the use of VRS in disaster training and an exploration of areas of learning where VRS may be an applicable pedagogy in nursing education. Larger studies involving more subjects and varied VRS delivery methods are essential. Additional studies are needed with more longitudinal data to explore the stability of the learning effect.

Conceptual framework

Situated learning theory guided this study. While the model was not tested, the findings of the study serve to inform the model. Central to the theory are the concepts of embodiment (cognition is dependent on the sensorimotor brain and body), embeddedness (cognition is fixed in context specific representations) and extension (cognitive systems exist in a physical and social environment) (Robbins & Aydede, 2009). The participants reported feeling both

immersed and a sense of realism as they interacted with VRS. These accounts support the processes of embodiment, embeddedness and extension needed for situated cognition. When situated cognition occurs, learners who are immersed in context of their domain of learning have better learning outcomes (Brown, Collins & Duguid, 1989). The overall positive significant effect of the VRS on learning supports the theory of situation learning.

Manuscript Three: Translation of Findings into Practice

Chapter four contains the final manuscript which describes the translation of the research findings into practice. The STAR method was used to identify strategies to integrate the research findings into practice. The model identifies five key stages to transform knowledge (i.e. research) into practice. The first stage is that of knowledge discovery. In stage two, evidence is summarized into a meaningful statement. The third stage results in the development of practice guidelines and recommendations. The fourth stage of the model includes the integration of the strategy into practice. In the final stage outcomes are evaluated (Stevens, 2004).

The first stage, knowledge discovery, has been presented in the findings manuscript. In stage two, the evidence of the current study was summarized into the following statement: The positive effect of VRS on retention has strong implications for the practice of nursing education. In the following paragraphs, practice guidelines (stage three), integration strategies (stage four) and evaluation (stage five) are discussed.

Practice guidelines.

To implement a VRS within a nursing education program both technology and education experts are essential. Content experts identify the domain of learning for the simulation. Appropriate measurable learning objectives are then developed. From the objectives the specific content of simulation is determined. A story board is created for scripting of the scenarios

including: activities, challenges, redirection, narration and evaluation of performance which facilitate learning and retention of content (Van der Spek, Wouers, & Van Ostedendorp, 2010). As the VRS is designed, education experts ensure that the simulation 1) will support construction of knowledge, 2) scaffold content to provide immediate availability of help, intentional assisting and expert modeling (Zhao & Orey, 1999), 3) provide coaching and, 4) promote reflection and abstraction and 5) integrate assessment of learning tasks (Herrington & Oliver, 1995). After the development of content and simulation scripting, the simulation is articulated into the virtual environment and pilot testing begins. Results of pilot testing are then used to revise and refine the VRS experience.

Two aspects of the simulation design are critical to the success of the VRS, participant presence (degree of immersion) within the simulation and the 3D multimodal interaction (participant usability) (Kim, 2005). Many systems are available for VRS delivery including a range of modalities from total immersion in special rooms to less immersive environments using monitor, keyboard and mouse (Strangman, & Hall, 2003). Early discussions regarding the method of VRS are critical. In addition, technology experts can assist educators in choosing the appropriate method of VRS delivery.

Reflecting on the theory of situated cognition, elements to consider when selecting the VRS system include facilitation of: 1) embeddedness (cognition is fixed in content specific representations), 2) extension (individuals exist in social and physical environments), and 3) embodiment (cognition is linked to the sensorimotor brain and body) (Robbins & Aydede, 2009). The depth and breadth of information that needs expressed (audio, visual, touch) to achieve appropriate levels of realism needs also be assessed (Steuer, 1992). Inclusion of all three of these elements is optimal, but not always practical; effective simulations may include only audio

and visual components. Overall, the designers need to consider what degree of immersiveness is needed within the simulation to achieve learning outcomes.

Integration into practice.

VRS has the ability to replicate actual buildings and areas into realistic scenarios. It allows individuals to safely participate in situations and events that could be difficult or impossible to experience in real life. There are a variety of potential applications for VRS in nursing education. In the case of disaster training, a wide selection of disaster situations can be modeled including both manmade and natural disasters. VRS allows participants the opportunity to repeat scenarios with both summative and formative evaluation.

However, integration of VRS into disaster training poses some challenges. Creation of VRS is costly and requires specialized training to develop, but once produced these scenarios can be used repeatedly by many participants. Important constraints in the use of VRS are that learners must have access to appropriate technology to take part in the VRS and both educators and students must be trained in the use of the VRS.

Evaluation.

As VRS is translated into practice, further research is needed regarding this educational strategy. Given that most hospitals have mandatory annual staff training, knowledge retention studies spanning at least one year. Research questions that need to be considered include: in length are highly recommended. In addition, research must be performed that examines whether the knowledge presented in VRS is translated into actual performance behaviors in real disasters.

Other aspects pertaining to VRS that need closer scrutiny include the analysis of the efficiency, effectiveness, and cost of the various types of VRS delivery systems (e.g., CAVE total immersion, monitor-keyboard and mouse). Plus, delivery systems should be investigated

for the following: immersiveness of simulation, use of single versus multiplayer view points and usability designs of the VRS systems. Research should also evaluate the variety of methods available for VRS and determine which are most effective in delivering content and providing realistic experiences for learners. Research questions which need to be considered include: What type of virtual reality systems are most cost effective, portable, yet produce desired learning outcomes? What content is best taught with virtual simulation? Should future studies focusing on triage also consider other circumstances such as decontamination and patient transport when appropriate?

Moreover, there is a need to determine which pedagogical programs and learning theories are supported by virtual simulation. Additional research questions include: How are both learning and retention affected by participation in virtual disaster environments? How do feelings of immersion, presence, and viewpoint effect learning and retention? Is autonomous learning or collaborative learning in the virtual reality environment superior? Virtual simulation is a new learning strategy with the increased emphasis on digital media, social networks, and gaming as viable teaching strategies, it is imperative that nurse researchers perform targeted investigations to expand the body of evidence regarding these educational approaches.

Research Trajectory

The original purpose of this study was to examine the longitudinal effects of virtual reality simulation (VRS) on learning outcomes and learning retention of disaster training with Associate Degree nursing students. The research on VRS added to the body of scientific evidence by demonstrating the positive effects on learning and retention. In the future, the researcher intends to pursue a research trajectory which includes continued study of VRS and disaster training. The VRS in forthcoming studies will have increased participant usability and

immersion. The VRS in present study had limited generalizability due to the use of convenience sampling. New research strategies will include studies using probability sampling involving varied healthcare professionals. In addition, investigations of longer duration with increased dosing of the VRS will be conducted. Multiple methods of measuring knowledge and retention will also be used including the cognitive, psychomotor and affective domains. Even though most simulation studies involving VRS have a triage scenario, this researcher's future investigations will explore other topics such as evacuation and psychological first aid. Although the study of VRS is very new, there are tremendous opportunities for nurse researchers and educators to develop, investigate, and improve this valuable teaching strategy.

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Appendix A



Recruiting Letter

Dear Student,

Date

My name is Sherry Farra and I am faculty at the Community College and a doctoral student at the University of Cincinnati. I am conducting a research study to determine the effect of a virtual disaster simulation on disaster training. This study is sponsored by the Community College and the University Of Cincinnati College Of Nursing.

Participants selected for this study are student nurses participating in the disaster training course. Students who agree to participate will choose the "Simulation Study" course. Students who do not wish to participate will choose the "Traditional" course. The disaster course, virtual simulation and pre/post assessments will be available on the ANGEL website through the student community site. After completing the online modules for the disaster course, students will be asked to take a pre-assessment, post assessment and a two-month post assessment. Assessments will be administered with anonymous results. A reminder to take the two-month post assessment will be posted on the student community site and a \$10.00 Starbucks gift card will be available from the nursing office as compensation for your time. Participants will receive a \$10.00 gift card at the end of the study, regardless of their completion of the study. The tests results are completely confidential and participants will be asked not to include their name or any other identifiable information on the assessment. Results from this study will be reported as aggregate data and no individual identities will be used in any reports or publications from this study. Participation or non-participation is voluntary and student participation or nonparticipation will not affect the student' grade in the course. There will be no tracking of participation in the courses.

If you have any questions about this research study, you may contact: Sherry Farra RN MS at 554-#### or the University of Cincinnati Instructional Review Board at (513) 558-5105. Thank you very much for your cooperation and assistance in this endeavor.

Appendix B

Adult Consent Form for Research

University of Cincinnati

Department: Nursing

Principal Investigator: Sharon Farra RN PhDc

Faculty Advisor: Elaine Miller PhD, RN, CRRN, FAHA, FAAN

Title of Study: Effects of Disaster Training With and Without Virtual Simulation

Introduction:

You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

Who is doing this research study?

The person in charge of this research study is Sharon Farra who is a doctoral student at the University of Cincinnati (UC) College of Nursing. She is being guided in this research by Dr. Elaine Miller, Ms. Farra's advisor.

What is the purpose of this research study?

The purpose of this research study is to compare the teaching effectiveness and learner retention of web-based disaster training augmented with virtual reality simulation to web-based training without simulation.

Who will be in this research study?

Up to 80 people will take part in this study. The participants in this study will be second-year nursing students enrolled at Sinclair Community College. You may be in this study if are over 18 years of age and able to speak English; have had no previous disaster training or physical limitations preventing participation in virtual simulation.

What will you be asked to do in this research study, and how long will it take?

You will be assigned to one of two groups. One group will complete web-based disaster training modules alone. The other will complete both the web-based disaster training modules and a virtually simulated disaster challenge. Learning will be measured using pre assessment prior to training, a post assessment immediately following training and an assessment two months post training. The virtual simulation will take approximately 45 minutes. Each assessment will take approximately 10-15 minutes.

Are there any risks to being in this research study?

It is not expected that you will experience any risk greater than that of your normal daily activities. There is a possibility that you could be frustrated with the virtual simulation.

There is a possibility that you could feel embarrassment due to a low test score.

To reduce the possibility of risk, you may quit the simulation at any time and all assessments will be scored anonymously.

Are there any benefits from being in this research study?

Some students within the study will receive additional disaster training within the virtual environment which may increase their understanding and retention of disaster training. Students who do not receive the virtual simulation training will receive no direct benefit from participation in this study.

What will you get because of being in this research study?

Participants will receive a \$10.00 gift card at the end of the study, regardless of their completion of the study.

Do you have choices about taking part in this research study?

If you do not want to take part in this research study you may take the web-based disaster course that is designated as the traditional course.

How will your research information be kept confidential?

Information about your participation in this study will be kept confidential. The tracking system will be turned off in the web-modules so that faculty will not know whether you have chosen to participate in the study. All assessment data will be recorded as anonymous. You will enter a code word or phrase on each assessment so that the assessments can be linked together, but no one will know this information but you. No identifiers will link you to the assessment data or course participation.

Agents of the University of Cincinnati may inspect study records for audit or quality assurance purposes.

What are your legal rights in this research study?

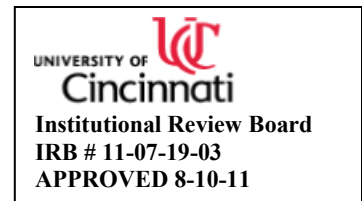
Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the institution, or its agents from liability for negligence.

What if you have questions about this research study?

If you have any questions or concerns about this research study, you should contact Sharon Farra at 937 ###-#### or Sharon.farra@sinclair.edu. Or you may contact Dr Elaine Miller at millerel@ucmail.uc.edu

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your rights as a participant or complaints about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.



Do you HAVE to take part in this research study?

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have.

You may start and then change your mind and stop at any time. To stop being in the study, you should stop participating in the “Simulation Study” web-based modules and take the “Traditional” web-based modules.

Agreement:

BY TAKING PART IN THE WEB BASED MODULES AND ASSESSMENTS DESIGNATED AS “STUDY MODULES” YOU INDICATE YOUR CONSENT FOR YOUR ANSWERS TO BE USED IN THIS RESEARCH STUDY.

PLEASE PRINT AND KEEP THIS INFORMATION SHEET FOR YOUR REFERENCE

ON ELECTRONIC VERSION ONLY:

Please indicate your consent to participate in this research by clicking yes.

- ☐ YES
- ☐ No (If no is selected a “pop up” text will direct students to “Traditional” disaster study modules).

Appendix C

Demographic Questions

Name:	
Are you 18 years of age or older?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Indicate your age group:	<input type="checkbox"/> 18-25 <input type="checkbox"/> 26-33 <input type="checkbox"/> 34-41 <input type="checkbox"/> 42-49 <input type="checkbox"/> 50+
Have you had paramedic training?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Have you had previous disaster training certification?	<input type="checkbox"/> Yes <input type="checkbox"/> No

Appendix D
Web-based Modules

Objectives based on *Educational competencies for registered nurses responding to mass casualty incidents* (International Nursing Coalition for Mass Casualty Education, 2003).

Module	Objectives	Content	Method	Evaluation
Module 1: Disaster Overview	<p>Distinguish the terms disaster and mass casualty incident (MCI) in relation to other major incidents or emergency situations.</p> <p>Identify special groups of patients that are uniquely vulnerable during a MCI</p> <p>Describe the local chain of command and management system for emergency response during a MCI.</p> <p>Describe the interaction between hospital, local, state and federal emergency response systems.</p> <p>Identify the registered nurses roles in MCIs.</p>	<p>Disaster and mass casualty incident (MCI)</p> <p>Risk Communication</p> <p>Vulnerable populations: very young, aged, immunosuppressed, chronic illness</p> <p>Elements of Unified Incident Command</p> <p>FEMA, State, local health departments, hospital disaster plan, personal preparedness</p> <p>Brief review of the role of the nurses in MCI: Epidemiologist, First Responder, Direct care provider, generalist nurse, Direct care provider, advanced practice nurse,</p>	<p>Web-based modules with voice over power point. (Additional opportunities)</p> <p>(Matching exercise)</p> <p>(Examples of hospital emergency plan)</p>	Pre-posttest multiple choice questions. Student evaluations.

		<p>administrator or emergency department nurse manager, On-site coordinator of care/incident commander, On-site director of care management, the role of the generalist nurse, Mental health counselor, Member of planning response team, Manager or coordinator of shelter, Member of decontamination team, Triage officer</p> <p>Role of the Associate Degree Nurse in MCI</p>		
	<p>Identify the limits to one's own knowledge/skills/abilities/authority related to MCIs.</p> <p>Utilize the START triage method to classify patients</p>	<p>Difference from hospital triage</p> <p>Overview START triage method</p> <p>Respirations, Perfusion, Mentation (RPM)</p> <p>Pediatric cases (JUMP START)</p>	<p>(Case scenarios)</p>	
	<p>Discuss the principles of containment and decontamination.</p>	<p>Decontamination</p> <ul style="list-style-type: none"> -Hot zone, warm zone, cold zone -Types of decontamination -Mass decontamination -hypothermia -vulnerable populations -eye care 	<p>(Video)</p>	

	Demonstrate the ability to access up-to-date information regarding selected nuclear, biological, chemical, explosive, and incendiary agents.	-environmental concerns Sources of current and reliable disaster information	CDC website FEMA website Department of Homeland Security website	
Module 2: Chemical events	Describe the essential elements included in a chemical event scene assessment. Assess the need for and initiate the decontamination procedures available, ensuring that all parties understand the need. Discuss the principles of containment and decontamination in chemical exposure. Identify the types of chemical agents and their effects. Identify general treatment and antidotes for	Review scene assessment: Odors, Clusters of symptoms. Evacuation uphill/upwind Appropriate personal protection (PPE) equipment/training Level B Level A Respiratory protection Decontamination Types of agents Signs and symptoms of exposure -Nerve agents -Pulmonary agents -Blistering agents -Blood agents Nerve agents- Paralidoxime Blood agents	Web-based modules with voice over power point. (FEMA chart, print PDF handout) (CDC charts, Print PDF handouts)	Pre-post test multiple choice questions. Student evaluations.

	specific agents.			
Module 3: Biological agents	<p>Describe the essential elements included in a biologic event scene assessment.</p> <p>Identify the type A category biologic agents and major responses to infection.</p> <p>Assess the need for and initiate appropriate isolation procedures and use of PPE procedures available, ensuring that all parties understand the need.</p> <p>Identify general treatment for specific biologic agents.</p>	<p>Scene Assessment: Clustering of symptoms, patterns of unusual illness Types of Agents: Naturally occurring/weaponized</p> <p>CDC Type A agents (signs/symptoms) -Smallpox -Botulism -Tularemia typhoid -Viral Hemorrhagic fevers -Plague</p> <p>Agent specific isolation and PPE</p> <p>Decontamination</p> <p>Treatment for specific agents Small pox-vaccine administration Anthrax- Viral Hemorrhagic fever Plague</p>	<p>Web-based modules with voice over power point.</p> <p>(CDC charts, Print PDF handouts)</p> <p>(CDC charts, Print PDF handouts)</p> <p>(CDC charts, Print PDF handouts)</p>	Pre-post test multiple choice questions. Student evaluations

Module 4: Radiologic events	<p>Describe the essential elements included in a radiologic event scene assessment.</p> <p>Discuss the principles of radiation safety, containment and decontamination.</p> <p>Identify the signs and symptoms of mild, moderate, and severe radiation exposure.</p> <p>Describe the treatment for radiation exposed patients.</p>	<p>Scene Assessment: Uphill/Upwind Radiologic Surveys</p> <p>Safety Concepts time, distance shielding. Exposure versus contamination Decontamination: External/Internal</p> <p>Signs and symptoms of radiation exposure Nurses role in documenting onset of vomiting, temperature, obtaining serial CBC</p> <p>Treatment Combined injury Colony stimulating agents</p>	<p>Web-based modules with voice over power point</p> <p>(CDC video)</p> <p>(Lymphocyte nomogram, printable PDF)</p>	Pre-post test multiple choice questions. Student evaluations
Module 5: Blast victims/ Natural disasters/ Psychological First Aid	<p>Differentiate high order (HE) and lower order (LE) explosive effects.</p> <p>Describe the essential elements of scene safety following an explosive event.</p> <p>Identify four types of blast injury.</p> <p>Describe the</p>	<p>Classification of explosives (HE & LE)</p> <p>Scene safety, radiation risks, structural damage</p> <p>Primary, Secondary, Tertiary, Quaternary blast injury</p> <p>Select primary blast</p>	Web-based modules with voice over power point	Pre-post test multiple choice questions. Student evaluations

	<p>general symptoms of select primary blast injuries.</p> <p>Identify potential natural disasters.</p> <p>Identify general first aid treatment for specific injuries.</p> <p>Describe the psychological impact on survivors, responders and health care providers.</p>	<p>injuries: Blast lung, bowel perforation, concussion, embolism, and tympanic membrane rupture</p> <p>Overview Earthquakes, tsunamis, tornadoes, hurricanes, floods, forest fires -Alert communication</p> <p>First aid: Crush injuries Broken bones Lacerations Penetrating injuries Drowning Burns</p> <p>Psychological First Aid -assessment -referral</p>		
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Appendix E

Virtual Simulations*

Objectives based on *Educational competencies for registered nurses responding to mass casualty incidents* (International Nursing Coalition for Mass Casualty Education, 2003).

<p>Scenario: Explosion at Air Force Base Setting: Air Force Base Fidelity: Realistic images of the Base. Age appropriate victims. Narrative: Working at the base hospital a loud explosion is heard with screams. Moving to the scene the student finds many injured people. The student is asked to help perform triage by the incident commander. Characters: 10 injured, varying levels of injury, incident commander</p>			
Objective	Challenge	Skills	Performance Feedback
Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.	Establish scene safety.	Assess for potential hazards.	Redirect for failure to begin with safety assessment.
Demonstrate knowledge and skill related to personal protection and safety, including the use of Personal Protective Equipment (PPE).	Ensure personal protection.	Don appropriate PPE.	Redirect for failure to use standard precautions.
Assess the need for and initiate the appropriate isolation and decontamination procedures available.	Determine the need for isolation or decontamination.	Detect presence of chemical or radioactive event. (Prompts to ask incident commander).	Redirect for failure to assess for chemical or radioactive event.
Demonstrate ability to perform START triage.	Utilize START triage process.	Call for ambulatory patients to move to safe area. Call for patients to wave	Redirect for failure to move ambulatory patients. Redirect for failure to

		or acknowledge. Move to nonmoving victims. Perform Respiration, Perfusion, Mentation (RPM) assessment of eight victims. Reposition airway if not breathing. Apply pressure to control hemorrhage. Identify correct triage category.	assess for ability to respond to commands. Redirect for failure to begin triage with immediate patients. Redirect for failure to perform RPM. Redirect for failure to reposition airway. Redirect for failure to control hemorrhage. Redirect for incorrect triage category.
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Scenario: Decontamination of explosion victim

Setting: Hospital Emergency Room and outside the Emergency room at the Air Force Base

Fidelity: Realistic images of hospital emergency room and ambulance area

Narrative: The student is moved to working in the hospital ER. The staff has been informed that the victims of the explosion may be contaminated with radiation. The student is caring for victim with severe nausea and vomiting as he is brought to ER

Characters: 1 victim, radiation safety officer

Objective	Challenge	Skills	Performance Feedback
Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.	Assess scene safety and identify the warm zone and cold zone.	Victims must be kept outside until their clothes are removed.	Redirect if patients are brought into the ER before clothes removed.
Demonstrate knowledge and skill related to personal protection and safety, including the use of	Recognize the need for impermeable gown and n-95 mask.	Don impermeable gown and N-95 mask.	Redirect for any level of PPE other than n-95 mask and impermeable gown.

<p>Personal Protective Equipment.</p> <p>Assess the need for and initiate the appropriate decontamination procedures available.</p>	<p>Determine the need for decontamination and decontaminate patient.</p>	<p>Cut and remove all clothing (top to bottom) and cover with blanket.</p> <p>Move patient inside ER.</p> <p>Wash skin immediately with soap and warm water. Gentle scrubbing, with head, face and hands first. <i>Radiations safety officer states level is less than twice background.</i></p> <p>Flush the eyes with tepid water for 5 to 10 minutes by tilting the head to the side, pulling eyelids apart with fingers, and pouring water slowly into eyes.</p>	<p>Redirect for failure to remove clothes, removal other than top to bottom.</p> <p>Redirect for failure to move patient inside.</p> <p>Redirect for failure to wash starting with face and hands.</p> <p>Redirect for failure to rinse eyes.</p>
<p>Identify the signs and symptoms of mild, moderate, and severe radiation exposure.</p>	<p>Determine level of radiation exposure based upon symptoms.</p>	<p>Assess for time of onset of nausea and vomiting (within minutes), temperature (102) and obtain lymphocyte count.</p> <p>Classify potential radiation exposure.</p>	<p>Redirect for failure to assess for nausea and vomiting, temperature or obtain lymphocyte count.</p> <p>Redirect for classification other than severe exposure.</p>

Appendix F

Objectives based on *Educational competencies for registered nurses responding to mass casualty incidents* (International Nursing Coalition for Mass Casualty Education, 2003).

Nursing: Disaster Preparedness

PRE/POST Assessments:

The competency is above each question, taxonomy/stage of nursing process precede the question. The correct answer is in italics.

Competency:

- **Use an ethical and nationally approved framework to support decision-making and prioritizing needed in disaster situations.**
 1. **(Knowledge/Planning)** The goal in a mass casualty incident is to:
 - A. Do the best for each victim.
 - B. *Do the greatest good for the greatest number of victims.*
 - C. Transport all patients as quickly as possible.
 - D. Assist the most acute victims first.
- **Describe accepted triage principles specific to mass casualty incidents, (e.g. the START or Simple Triage and Rapid Treatment system).**
 2. **(Application/Assessment)** The nurse using the START triage method would classify which of the following patients as immediate?
 - A. 30-year-old with a compound fracture of left tibia, respirations 28, capillary refill of less than 2 seconds, awake and screaming for help.
 - B. 13-year-old with an amputated finger with controlled bleeding, respirations 22, capillary refill of 1 second.
 - C. *23-year-old with head injury, rapid respirations of 36, with altered mental status and capillary refill of 3 seconds.*
 - D. 45-year-old with facial injury, respirations 26, alert and oriented, capillary refill of 1 second.
- **Describe accepted triage principles specific to mass casualty incidents, e.g. the START or Simple Triage and Rapid Treatment system.**
 3. **(Application/Evaluation)** You arrive on the scene where START triage has been performed. You are assisting in patient transport. Which of the following patients would be sent to the hospital first?

- A. A female with head injury, screaming for help. The patient's tag is yellow.
 - B. An unresponsive female who does not appear to be breathing. The patient's tag is black.
 - C. *An unconscious male, with an obvious compound fracture of the leg. The patient's tag is red.*
 - D. An ambulatory female who is expressing fear of radiologic exposure. The individual does not have a tag.
- **Describe accepted triage principles specific to mass casualty incidents, e.g. the START or Simple Triage and Rapid Treatment system.**
4. **(Application/Assessment)** The nurse using the START triage method would classify which of the following patients as minor?

A victim with:

- A. *Scalp laceration with controlled bleeding, respirations 24, capillary refill of <2 seconds, alert walked to designated area.*
 - B. Abrasions, respirations 36, capillary refill of 3 seconds, alert and answers questions appropriately does not move to designated area.
 - C. Burn to left arm and face, respirations 40, capillary refill is sluggish, normal level of consciousness.
 - D. Spurting blood from neck injury, respirations 38, rapid pulse, and slow capillary refill >3seconds.
- **Describe accepted triage principles specific to mass casualty incidents, e.g. the START or Simple Triage and Rapid Treatment system.**
 - **Describe general signs and symptoms of exposure to selected chemical, biological, radiological, nuclear, and explosive agents (CBRNE).**
5. **(Application/Assessment)** The nurse using the START triage method would classify which of the following patients as expectant?
- A. A 44 year old male with nausea and vomiting six hours post exposure to radiation with complaints of chest pain.
 - B. A pregnant 22 year old female with a WBC of 5.6, 12 hours following exposure to a radioactive source.
 - C. *A 32 year old female with immediate onset of nausea and vomiting after being contaminated with radioactive material.*

- D. An 86 year old male with no nausea and vomiting and normal WBC following radiation exposure.
- **Describe accepted triage principles specific to mass casualty incidents, e.g. the START or Simple Triage and Rapid Treatment system.**
6. **(Application/Assessment)** At the site of a disaster, the nurse using the START triage method would classify which of the following patients as delayed?
- A. Victim with facial injury who has moved to the designated area with respirations 24, 1 second capillary refill and normal level of consciousness.
 - B. *Victim complaining of leg pain, unable to move to designated area, respirations 28, 1.5 second capillary refill, who is alert and oriented.*
 - C. Victim with compound fracture of left femur with respirations of 44, pedal pulse absent, and is awake.
 - D. Victim who is unresponsive with no pulse or respirations.
- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**
7. **(Application/Implementation)** A client is brought to the emergency department with suspected recent exposure to a nerve agent. His clothes are saturated with the substance and he is experiencing a seizure, and is cyanotic. What should the nurse do first?
- A. Place the patient in a side lying position.
 - B. Place oxygen on the patient.
 - C. *Don appropriate personal protective equipment.*
 - D. Decontaminate the patient.
- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**
8. **(Application/Implementation)** In addition to standard precautions, a nurse should implement droplet precautions with which patient?
- A. 29 year old male admitted with descending facial paralysis.
 - B. 50 year old female admitted for a cutaneous anthrax lesion.
 - C. *46 year old male with pneumonic plague, with enlarged lymph nodes.*
 - D. 86 year old patient with known small pox exposure.

- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**
9. **(Application/Planning)** The nurse is assigned a client with newly diagnosed smallpox. The patient has a productive cough. Which of these interventions would be a priority intervention for the nurse to implement?
- A. Instruct the patient to cover their mouth when coughing.
 - B. Reinforce that everyone wash hands before and after entering the room.
 - C. *Place client in a negative pressure room and have all who enter use a respirator.*
 - D. Place the client in droplet precautions, and ensure anyone within 3 feet wears a surgical mask.
- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**
 - **Use clinical judgment and decision-making skills in assessing the potential for appropriate, individual ongoing-care after a mass casualty incident.**
10. **(Application/implementation)** Which of the following would you do first when treating a patient contaminated with radioactive materials and is in unstable condition?
- A. *Remove the patient's clothing*
 - B. Decontaminate the patient.
 - C. Provide medical stabilization.
 - D. Don a lead apron.
- **Describe general signs and symptoms of exposure to selected chemical, biological, radiological, nuclear, and explosive agents (CBRNE).**
11. **(Application/Assessment)** You are working in the emergency room when a 56-year-old male reports that he thinks he has chicken pox. When performing your assessment of the patient which of the following symptoms would cause you to suspect small pox?
- A. *Circular shaped lesions.*
 - B. Tear-drop shaped lesions.
 - C. Lesions on the face and trunk.
 - D. Absence of fever.
- **Describe at the pre-disaster, emergency and post-disaster phases the essential nursing care for:**
 - individuals,

- families,
- special groups, e.g. children, elderly, pregnant women; and
- communities.

12. **(Knowledge/ Evaluation)** The mitigation phase of disaster management encompasses all of these except:

- A. Determination of the resources available for care to infants, the older client, the disabled, those with chronic health problems.
- B. *Measures that can prevent the occurrence of a disaster or reduce the damaging effects of a disaster.*
- C. Determination of the community hazards and community risks before a disaster occurs.
- D. Practice of community disaster plans.

- **Describe general signs and symptoms of exposure to selected chemical, biological, radiological, nuclear, and explosive agents (CBRNE).**

13. **(Application/diagnosis)** When treating a patient who has been exposed to cyanide which of the following is the highest **priority** nursing?

- A. Risk for injury related to seizures.
- B. *Altered tissue perfusion related to inability of cells to use oxygen.*
- C. Nausea related to parasympathetic stimulation.
- D. Fluid volume deficit related to vomiting.

- **Use clinical judgment and decision-making skills in assessing the potential for appropriate, timely individual care during a mass casualty incident**

14. **(Application/Planning)** The nurse is notified that there has been a possible anthrax attack on a city bus and to prepare for a large influx of patients. Which of the following should be made easily available?

- A. *Ciprofloxacin*
- B. 2-PAM
- C. Anthrax vaccine
- D. Atropine

- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**

15. **(Application/Implementation)** You are working in the Emergency room. There has been a chemical event with mass casualties. Which of the following is true?
- A. Only decontaminated patients should be in the Red zone.
 - B. *You should remove PPE before proceeding into the Green zone.*
 - C. Patients should have clothes removed in the Yellow zone.
 - D. Decontamination occurs in the Green zone.
- **Assess the safety issues for self, the response team, and victims in any given response situation in collaboration with the incident response team.**
16. **(Application/Implementation)** A radioactive source was placed in a classroom. Students have been in and out of the room all day. Some of the students have come to the emergency room where you work. They are displaying signs of radiation exposure. What PPE should be worn by the nurse caring for these patients?
- A. *Standard precautions*
 - B. N-95 mask, gloves and impermeable gown
 - C. Surgical mask and gloves
 - D. Plastic suit, with self contained breathing apparatus
- **Describe general signs and symptoms of exposure to selected chemical, biological, radiological, nuclear, and explosive agents (CBRNE).**
17. **(Application/Assessment)** Which of the following indicates that the patient has suffered a primary blast injury:
- A. Object penetrating the left eye
 - B. Concussion from collision with a wall
 - C. Radiation sickness
 - D. *Pulmonary hemorrhage*
- **Identify possible indicators of a mass exposure (i.e., clustering of individuals with the same symptoms)**
18. **(Application/Diagnosing)** An emergency room nurse is working when there is a bioterrorism attack in the city. Which of the following statements is a correct with regard to injuries or symptoms associated with a bioterrorism attack?
- A. The main purpose of biological weapon use is contained devastation.
 - B. *Illness may present as clusters of individuals with the similar symptoms.*

- C. Biological attacks are usually known right away.
- D. Detection is easy as clients go to a number of different health care facilities.

- **Use clinical judgment and decision-making skills in assessing the potential for appropriate, timely individual care during a mass casualty incident.**

19. **(Application/implementation)** There has been a radioactive explosion nearby. The emergency room nurse must triage and manage the decontamination of the clients systematically. Which of the following clients would be decontaminated first?

- A. An individual with severe injuries.
- B. *The walking wounded.*
- C. Those with life-threatening injuries.
- D. Those triaged as expectant.

- **Identify one's own role in the emergency response plan for the place of employment.**
- **Discuss security and confidentiality during a MCI.**

20. **(Comprehension/Planning)** An emergency room nurse is at work when a major terrorist attack occurs. In addition to caring for injured clients, there must be crowd control. Which of the following statements, if made by the nurse, demonstrates an understanding of the concept of crowd control?

- A. "The job of crowd control is under the auspices of the nurses."
- B. "Even if the crowd control is maintained, chaos ensues."
- C. *"The agency's security personnel and/or the local police force must control these crowds."*
- D. Nurses will need to enter areas that have not been secured yet in order to reach the clients.