IMMERSIVE LEARNING IN EDUCATION FOR CPR SKILLS ACQUISITION

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by

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IMMERSIVE LEARNING IN EDUCATION FOR CPR SKILLS ACQUISITION

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DEDICATION

To my family. Their support means everything to me. My mother, Bear, has always believed in me and is the strongest woman I know. My children, Jolyna and Logan, you are both my beautiful shining lights and I appreciate you both each and every day. Mark, my husband, thank you for your endless support and encouragement. To my sister Aja, all my nieces and nephews, my father, my uncles, and my late grandparents – you have all been so important in my journey. I keep you in my heart.

ABSTRACT

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This quasi-experimental research study 1) explored the effectiveness of implementing a Virtual Reality CPR simulation for improving knowledge and skills on the Basic Life Support exam and 2) explored the favorability of using a CPR VR simulation for recertification as measured through a self-efficacy survey instrument. Participants included staff, faculty, or students at a small liberal arts college located in the southeast United States seeking re-certification in CPR. This study was conducted in the following steps; 1) conducted literature review that encompasses opportunities in CPR training, opportunities in VR, games and simulations in education, implementation challenges, and research opportunities and frameworks 2) applied for approval from the IRB at both Sam Houston State University and the participating college 3) acquired Oculus Go VR headsets and install the simulation software on each device 4) recruited an instructor and participants to participate in the study 5) scheduled classes and reserve facilities 6) conduct the study and analyze the data. This study provided evidence of the efficacy and favorability of using a CPR VR simulation as part of a CPR recertification course.

KEYWORDS: CPR training, Virtual reality, Immersive virtual reality, Virtual reality headset, Embodied learning, Learning engagement, Ethics in VR, Safety in VR, Simulation

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CHAPTER I

Introduction

Technology tools have, in recent years, become ubiquitous in education. Educational environments are currently being impacted by many technology shifts, including advancement of technology availability and innovation and the cultural shifts associated with our current global pandemic that began late in 2019. Educators and students find themselves in a continuous learning opportunity cycle that allows education to enter into modalities that have not before been experienced at the scope they have morphed into today. Virtual reality (VR) is one example of such technology that can create immersive learning environments for students to learn many things, including but not limited to content and procedural skills. Immersive learning applications provide embodied experiences using touch and gesture technology, which may cement learning in a deeper and longer-lasting manner compared to traditional educational methods such as video, direct lecture, or textbook reading (Araiza-Alba et al., 2021; Chang et al., 2016). This study lend understanding as to the efficacy of the immersive learning modality for adult learners.

The included literature review pinpoints an appropriate conceptual and theoretical framework upon which this study can be examined and then examines opportunities that have recently come available in VR and haptic touch technologies in education, relevant literature about procedural learning in immersive environments, and implementation issues and challenges. This study examined the efficacy of using a VR simulation, “Saving Lives”, as supplemental instructional support in addition to a traditional learning modality to convey vocabulary and skills needed for participants completing cardiopulmonary resuscitation (CPR) recertification training.

This research study explored the efficacy of Virtual Reality for adult learning using the Oculus Go stand-alone headset system compared to traditional teaching strategies among students in learning CPR skills and vocabulary as well as feeling confident in their own abilities to perform CPR. Challenges and opportunities for implementation were also examined to add to the database of literature regarding teaching and learning strategies that leverage immersive VR.

Today’s technology-rich society offers innovative tools that can assist students in learning more effectively inside engaging learning environments; thus, technology may help educators teach more effectively. In particular, I am interested in immersive learning in the education sector and whether it can be effective as a learning modality. Virtual Reality is a technology that is only recently widely available to the public and has enormous potential for learning in a multi-sensory manner. VR allows learners to leverage more immersive experiences, which can help them fully benefit from the learning experience. The power of VR lies in that it enables students to learn through multiple senses, engaging the brain in multiple ways that cement learning. For example, a student can see, feel, and hear simultaneously in the immersive environment.

VR requires that students do not see the world outside of the immersive environment, so their ability to pay attention is heightened with less distraction. Since the use of VR as a learning environment has only emerged recently in traditional education settings, a study that can assess the efficacy of this new learning environment when compared to conventional environments would address gaps in the literature (Gordon et al., 2019; Legault et al., 2019; & Pavlik, 2017). Although VR and AR technology research with CPR is not yet mature, the field is ripe for research since this emerging technology presents excellent opportunities for researchers interested in VR for healthcare applications.

While VR can be implemented in many different disciplines to facilitate learning, the present study examined procedural knowledge and skill acquisition among personnel employed at a small liberal arts school interested in becoming re-certified in CPR. This study used qualitative and quantitative methods to give evidence for or against the efficacy of VR as a supplemental learning modality for skills and procedural knowledge acquisition for students learning CPR.

CPR Training

CPR training has been available through the American Heart Association (AHA) and the American Red Cross (ARC) for several decades, and many training modalities are available. These include mobile, game-based, and in-person courses, self-paced video training and fully online courses; however, a more effective training system is needed since "rigorous evaluation of their efficacy is lacking" (Brown & Halperin, 2018, p. 1). While over 350,000 Americans experience a cardiac arrest annually, less than 3 percent of the population receives training each year in recognizing an attack and assisting someone. Furthermore, many adults are certified in high school but do not receive any subsequent training. For example, I am in my forties and need a refresher as the last time I took CPR training was about 30 years ago. This incongruity indicates a great need for non-medical personnel to engage in CPR training, which will result in a more significant number of people saving lives (Brown & Halperin, 2018). In fact, "Saving Lives" is actually the name of the Oculus Go simulation that I studied.

Problem Statement

Students struggle to learn hands-on procedures with CPR through classroom experience alone, especially in the current environment where COVID-19 has made the ability to share learning mannequins less common. Even before the pandemic occurred, there had been a shortage of access to high-cost learning mannequins for all students to have ample practice time to perform the skills needed for CPR certification. In addition, students lack access to the instructor's physical presence and time with the learning mannequins, which severely inhibits time to practice skills and limits feedback provided to students. Virtual Reality hardware can remedy this problem since it increases the time allowed for each student to engage in immersive learning while also potentially cutting educators' costs. An Oculus VR headset in 2021 cost about $300 (Oculus, 2021), whereas a CPR learning mannequin with an LED feedback light in 2021 costs $495. Because VR headsets are substantially smaller than mannequins, disinfecting and transporting these learning tools should be factored in when considering which tool to adopt. While the virtual reality platform should not replace the mannequins altogether, it can offer a cost-effective solution for students to practice their skills, allowing flexibility in study and practice of the CPR skills (Buttussi et al., 2020). Accessibility to VR learning tools allows better efficiency in many areas including mitigating storage limitations, allowing students to practice skills before and after having access to the mannequin, and harnessing the flexibility of VR devices featuring multiple applications in addition to the "Saving Lives" CPR simulation so skills can be practiced on one single device (Buttussi et al., 2020). Not only can students learn CPR skills, but they can also use the headsets to engage in a variety of learning applications (Makransky & Petersen, 2021). This study explored the benefits and challenges of using immersive learning in the context of learning CPR skills with a Virtual Reality simulation called “Saving Lives” on the Oculus Go platform instead of using CPR mannequins alone. An added benefit to using VR headsets is that learners can participate in many more VR activities beyond the CPR simulation, allowing training and education organizations to leverage additional opportunities for learning through one device platform, thus cutting overall training and development costs.

Purpose of the Study

The purpose of this study is to assess the efficacy of using immersive learning environments to learn CPR skills in a classroom setting in addition to a learning mannequin. Surveys and assessment scores were used to analyze this VR learning environment's effectiveness compared to the traditional learning methods.

Methods

A certification test and post-test comparison were used to assess whether the immersive learning environment more effectively creates knowledge transfer when learning CPR. Additional qualitative data were collected in a modified self-efficacy survey that helped the researchers pinpoint variables such as confidence to perform the skill after training and belief in their personal skill sets regarding the content.

This study examines retention of content, self-efficacy, and learner experience while using immersive learning. This study informed current practices around teaching with immersive learning environments and explored the student experience regarding self-efficacy while engaging in the immersive learning experience. Practitioners gained insight into how immersive learning and VR can be effectively implemented into their teaching strategies.

Research Questions and Hypotheses

This research project addressed finding answers and implications for these research questions:

RQ1: What effect does the application of Virtual Reality as a supplement to traditional procedural training have on adult learning outcomes?

SubRQ1: How does the addition of a supplemental virtual reality simulation affect adult performance between groups in a recertification Cardiopulmonary Resuscitation (CPR) course as measured by the change in scores between an exit test and subsequent post-test comparison using the Basic Life Support certification exam?

RQ2: Does the additional modality of VR affect self-efficacy for adults in a CPR recertification course?

SubRQ2: When surveyed for self-efficacy, is there a significant difference between pre, post, and follow-up change of self-efficacy scores between groups?

Hypotheses:

Supplemental virtual reality simulation will improve CPR knowledge and skills performance in adult CPR recertification participants as measured by a test and post-test comparison as measured using the American Heart Association Basic Life Support certification exam.

Participants in the experimental group will report greater self-efficacy when surveyed two weeks after the CPR VR experience.

Significance of the Study

Little research has been conducted in using VR applications to supplement CPR instruction, so this study helped add to the literature regarding the use of VR to teach procedural and content knowledge. My experience is that professionals in higher education prefer to adopt only after they can ascertain that a technology implementation has been successful, because the time spent learning how to implement new strategies into their pedagogy can be a barrier. Professors need to see how a technology would benefit their students to determine whether they are willing to spend time and resources to plan and execute. This study may have far-reaching ramifications regarding the adoption of virtual reality settings in healthcare training, education, and beyond.

Key Term Definitions

Augmented Reality: Virtual content displayed within a user's real-world environment (Steffen et al., 2019).

AED: An Automatic External Defibrillator (AED) is a portable medical device that can assess and recommend whether a patient needs to receive an electric shock to restart the heart into normal cardiac rhythm and then, if recommended, administer the electric shock to the patient (American Heart Association, 2017).

CPR: What is CPR? (2022) defines Cardiopulmonary Resuscitation (CPR) as a procedure performed by a bystander or healthcare professional to increase a person's chance of survival after a heart attack.

Compression Rate: The American Heart Association (2022) recommends 100-120 chest compressions per minute.

Compression Depth: The American Heart Association (2022) recommends compression depth greater than 2 inches, and not exceeding 2.4 inches.

Engagement: Students perform learning activities supported by constructs such as "quality of effort", time spent, content involvement, and implementation of best practices (Kuh, 2009).

Immersive Learning: Learner is excluded from their real environment and instead senses presence in the virtual environment (Steffen et al., 2019).

Mannequin: A CPR learning mannequin with an LED feedback light is used for learners to practice CPR and receive immediate feedback about physical CPR skill performance.

VR Headset: According to Oculus (Oculus Blog, 2021), a VR headset uses different visual feeds for each eye along with stereo sound and motion inputs to create an immersive three-dimensional world for the viewer.

Recertification: The American Heart Association requires certification every two years.

Self-efficacy: A belief in one's personal abilities **(**Bandura, 1997).

Simulation: Training occurs outsider of a real-world environment, allowing participants to practice before the actual occurrence of an event (Perron et al., 2021).

Virtual Reality: Accessed with dedicated hardware, virtual reality (VR) immerses a person in a 3D experience (Oculus Blog, 2021; Steffen et al., 2019).

Organization of the Study

Approval was obtained from the Institutional Review Board (IRB) for the Protection of Human Subjects in Research at Sam Houston State University and the college of the participants' employment. Permission was also obtained from the Provost of the college to ensure that the study ran smoothly and that there is full transparency for the college.

CHAPTER II

Literature Review

Comprehensive Literature Review

This literature review first examines the conceptual frameworks that can be leveraged when planning educational VR research and then examines literature found using key search terms that include *CPR training, virtual reality, immersive virtual reality, virtual reality in education, mixed reality, virtual reality headset, haptic, educational games, serious games, embodied learning, vocabulary learning, learning engagement, ethics in VR, safety in VR.* Some common themes that emerge in this literature review include opportunities and challenges in CPR training, students struggling with academic vocabulary, opportunities that have recently come available in VR and haptics in education, serious games as effective teaching strategies, language learning efficacy in immersive environments, and implementation issues and challenges.

Conceptual and Theoretical Framework

A conceptual or theoretical framework is that which connects a theory to research. Several theories from the recent literature (outlined in Table 3) support immersive learning including constructivism, developmental learning theory, theory of deliberate practice, self-efficacy, affordances, cognitive load theory, the principles of multimedia instruction, and the Cognitive Affective Model of Immersive Learning. These theories support and expand upon one another to create a full picture of how learning happens and how VR designers and educational professionals can successfully implement this technology to achieve greater understanding. For this study, we examined immersive learning through these lenses.

Constructivism

Constructivism attempts to address the limitations of some previous learning theories, like behaviorism and social learning. While these two theories explain a great deal at a foundational level, cognitive thought and the power of free will are not considered. Immersive education can remedy this challenge since it inspires users to think about their surrounding simulated environment and make decisions in that environment. These two features allow more significant learning through the immersive modality.

Araiza-Alba et al. (2021) performed a study about learning problem-solving skills comparing gamified learning modalities of immersive virtual reality, tablet, or board game environments, finding that game completion occurred more frequently for those in the VR condition. Along with the idea that embodied cognition - the idea that our thinking is affected by what is happening to our physical senses - having a positive outcome on reducing cognitive load, constructivism is supported in the sense of presence where the learner feels as if they are actually in the experience (Araiza-Alba et al., 2021). This study positively supports learning in VR environments as a constructivist experience because simulation allows learners to feel like they are in a situation and can learn by doing and benefit from reduced cognitive load, which makes learning a more pleasant and rewarding experience.

Developmental Learning Theory

Jean Piaget’s developmental learning theory (also referred to as genetic epistemology) is a learner-centric cognitive idea that tells us that learning occurs through assimilation, accommodation, and equilibrium, which means that learners have specific schemata (mental models) that are modified through environmental and mental factors to create new cognitive understanding (Buttussi et al., 2020; Leonard, 2002). Thus, knowledge builds upon the knowledge already in place in the learner's mind. Immersive learning allows students to build upon prior knowledge and practice their skills through trial and error, constructing their new cognitive understanding with each learning attempt. Chen (2009) explains that the underlying learning theories of constructivism are appropriate for using immersive (or even non-immersive) virtual-reality tools to learn. They support positive learning experiences such as learner agency, choice, and focus.

Theory of Deliberate Practice

McDonald et al. (2021) outline an instructional design framework for virtual simulations beginning with the Theory of Deliberate Practice, which states that mastery is achieved through guided practice. In addition, Cognitive Load Theory supports the Theory of Deliberate Practice. They recommend designing educational tools in the most efficient way possible, allowing for learning without extraneous cognitive effort. Learning begins with simple concepts, which can then be related by a "chunking" strategy to form a schema that provides a mental model of the information organized efficiently so that the learner can more easily commit the information into long-term memory. Although McDonald et al. (2021) worked with developing skills for Social Work, this work supports the idea that learning in virtual environments should be designed to maximize the practice of skills to achieve mastery while reducing and managing the learner's cognitive load.

Self-efficacy

Buttussi et al. (2020) provide an excellent framework that can be modified to fit the current research in which 30 computer science students participated in CPR training with and without the CPR learning mannequin but all with the VR environment. The final assessment included performing CPR effectively on the training mannequin and completing a self-efficacy survey at three times during the study (Buttussi et al., 2020). In the analysis performed by Buttussi et al. (2020), participants not using the mannequin only lacked skills related to pressure of compressions but were better with procedural steps, and both groups showed increased self-efficacy after training. Since mannequins are expensive and generally are provided at a low ratio per student (i.e. one per 8-person class), the addition of the CPR simulation “Saving Lives” on the Oculus Go could help several students master procedural and time-related skills before they have access to the mannequin. With the inclusion of VR to learn rate of compressions, terminology, and sequence of steps in an emergency, students have the improved opportunity to learn the proper compression pressure once they are able to work with the mannequins. VR has the possibility of making training more efficient since participants can engage in this variety of skills practice in different modalities.

Affordances

The framework of affordances, from the seminal work of Gibson, postulates that people use AR and VR when activities become possible that could not otherwise be afforded in physical reality (Steffen et al., 2019). The opportunity that technology presents allows humans to engage with computers to simulate experiences that are unsafe, uncommon, or even impossible in physical reality. More broadly, Steffen et al.

describe affordances as relationships between living beings and their environments and the features that allow those beings to interact with said environments to achieve individual goals. Furthermore, they posit that the growing popularity of VR and AR signify that the physical world lacks affordances that allows users to reach their goals – thus, the extension of reality that these modalities provide allows humans to virtually modify their environment in an effort to reach goals. Virtual reality features several affordances that allow users to interact with the environments in meaningful ways including performance of skills that are not readily practiced in physical reality such as CPR. Four generalized affordances can be observed about virtual reality that illustrate the human need to modify reality to either overcome discomforts or enhance positive experiences; 1) diminish negative aspects, 2) enhance positive aspects, 3) recreate existing aspects, and 4) create aspects that do not exist. These are supported by modifiers which motivate users to engage with VR such as sensory vividness and physical context. Steffen et al. performed quantitative studies which compared AR, VR, and physical reality with regard to the affordances provided and discovered that VR had a higher preference rating for affordances 3 and 4 in both studies. Interestingly, AR was preferred with respect to filtering information, sensory vividness, and physical context. This study provides a firm foundation for both researchers and practitioners who study AR and VR, allowing them to choose the best modalities to harness that will help them to reach their intended goals.

Another study (Salzman et al., 1999) provides insight into use of the Affordances framework in designing VR interactions, and further relating the design to other factors such as learner experience, concepts to be learned, and learner characteristics. While the learning environment can host certain aspects, these do not work in isolation and are greatly affected by factors outside of the designer's control. This makes the design process particularly complex when aiming to meet the needs of all members of a learner audience, and a model is presented that explores how all of these factors knit together to form a pathway to meet learning outcomes through VR learning modalities.

Kaplan et al. (2020) postulate that across studies, traditional methods and VR methods both can adequately achieve learning outcomes and thus the inspiration to use VR should occur when 1) the VR environment can more effectively simulate the actual experience in which the learners must perform the concepts or skills gained, 2) situations do not yet exist, such as a trip to outer space or into a microscopic cell, and 3) actual situations that necessitate the performance in the real world are unsafe or uncomfortable. Thus, the benefits of extended reality training can surmount many obstacles and make training more effective – especially in situations that the skills can be learned in more comparable environments to the actual performance of the skills. The military has used simulation training for decades – pilots achieve flying competence sooner, soldiers can think more quickly in battlefield scenarios, and immediate feedback allows for learners to create accurate knowledge pathways instead of scaffolding off errors. One measure that is of particular importance is whether the training is applicable to the actual real-world performance of the task learned, a principle called "encoding specificity", originally explored by Tulving & Thompson in 1973. An example is given of a study that required learners to memorize terms about scuba diving in a classroom setting. Learners were able to pass the assessment in the classroom, but were unable to perform tasks correctly while scuba diving, which can lead to a very dangerous outcome when the assessment doesn't fit the learning outcomes. Kaplan et al. (2020) conclude that VR versus traditional training is comparable regarding performance, that audience and outcome can indicate VR as an appropriate modality, and that training transfer effects need further research.

Cognitive Load Theory

Cognitive load theory is based on biological evolution and how our brains react to stimuli through primary knowledge, which is instinctive, and supports secondary knowledge which is what can be learned (Sweller, 2011). Cognitive load is the information that is processed in working memory and is limited from three to seven individual elements of knowledge, which is referred to as cognitive limit – the total amount possible to be in working memory at one time. Maxing out the cognitive limit creates cognitive overload, which is detrimental to learning because our brains cannot process all of the elements. When we arrange information into larger chunks of understanding, this is referred to as schema – which is essential to understanding how learning works because schemas are stored into long term memory and are the prior knowledge elements that help a learner to understand more fully increasingly complex concepts. Working memory is limited and can be defined as what happens during processing after which only some information is converted into long term memory (which may be infinite in capacity) – it is this conversion from working memory into long term memory that is important to consider when thinking about learning. Larger amounts of information that must be processed creates a larger load on working memory, which in turn limits the amount of important information that is converted into long term memory. It is important then to design instruction to manage this cognitive load so that the learner can effectively gain the intended information and activate it into the working mental model housed in long term memory. Extra features can limit what is processed into long term memory and instead the learner may remember something that is unintentional and not part of the learning objective. Total cognitive load, which is what is needed to determine the amount of working memory needed to learn the material, is determined through the combination of intrinsic, extraneous, and germane load. Intrinsic load is the difficulty of the task for each learner as measured by the new elements in working memory, extraneous load is the unnecessary inclusion of unimportant elements that must also be processed by the learner, and germane load is what is needed to incorporate the new knowledge into the existing knowledge and house it all in the long-term memory. Some learning requires that the learner learn multiple concepts at once, which is known as “element interactivity”, and the higher this is, the more difficult it becomes to learn the complex concept. Instructional design must effectively manage cognitive load using teaching strategies that best allow the learner to succeed in achieving learning outcomes.

Several studies have been completed recently to try to ascertain the relationships between cognitive load and virtual reality applications. Andersen et al. (2016) performed a study with medical students using a mastoidectomy lesson and discovered that the cognitive load was too much because of the complex content, concluding that strategies that can chunk the content more effectively to manage cognitive load should be investigated.

Principles of Multimedia Instruction

Extending upon Cognitive Load Theory, Mayer's (2009) Twelve Principles of Multimedia Instruction also come into play with regard to designing learning applications in VR. The basic idea of this framework is that people learn better from words and pictures than simply words alone and further, that instructional design should be learner-centered rather than technology centered. A learner's cognitive load is managed in ways that allow more learning to occur because the barriers to learning are lessened using specific strategies that help learning to occur more efficiently. According to Mayer, there are three ways to address these issues of cognitive load: 1) Reduce extraneous processing load, 2) Manage essential processing load, and 3) Foster generative processing. Extraneous processing occurs when the learner's focus is on too many things and the essential content is missed because the learner's attention is elsewhere – this occurs when there is too much going on in a lesson and the learner misses out on the actual instructional goal. Essential processing overload occurs when the content matter is of a complex nature, the learning is rushed, or the learner is not ready for the content – thus, all attention is on trying to learn the shallow material and not being able to engage in deeper understanding to create a new schema. Generative processing occurs when the learner makes sense of the material, committing the knowledge into a deeper understanding. Knowledge, both new and past, is organized and constructed together to make a coherent understanding of the material and create a mental model for the learner. These principles, retrieved from Mayer's text on Multimedia Learning (2009) are meant to help manage cognitive processing and are outlined in Table 1.

Table 1

The Principles of Multimedia Instruction

Principle	People Learn Better When	Cognitive Goal
1. Coherence	Extra words, pictures, and audio should be excluded and not included.	Reduce extraneous processing
2. Signaling	Cues are added to highlight the organization of essential material.	Reduce extraneous processing
3. Redundancy	Graphics and narration alone are included instead of graphics, narration, and text.	Reduce extraneous processing
4. Spatial Contiguity	Corresponding words and pictures are closer together rather than further apart.	Reduce extraneous processing
5. Temporal Contiguity	Corresponding words and pictures are given at the same time rather than further apart in time.	Reduce extraneous processing
6. Segmenting	Modules are presented rather than one lengthy unit.	Manage essential processing
7. Pre-Training	Learners already know the names and characteristics of the main learning concepts.	Manage essential processing

Continued

Principle	People Learn Better When	Cognitive Goal
8. Modality	Present graphics with narrated rather than written words.	Manage essential processing
9. Multimedia	Words and pictures are presented rather than words alone.	Foster generative processing
10. Personalization	Words are more conversational and less formalized.	Foster generative processing
11. Voice	A human voice is used rather than an artificial computerized voice.	Foster generative processing
12. Image	The image of the speaker is extraneous and people do not learn better when they can see the person along with the content.	Foster generative processing

Since VR engages a user's senses in an immersive environment, it follows that VR can leverage learning in different ways other than video or computer learning modalities. If fact, a search with both VR and the Principles of Multimedia Instruction leads us into a pattern of research that makes several empirical observations over the last few years, as outlined in Table 2.

Table 2

Empirical Observations about VR and Multimedia Design

Observation	Evidence
Implementation of the pre-training principle had a positive effect on retention, transfer, and self-efficacy when using the immersive VR modality – thus methods can greatly impact the efficacy of the modality.	Mayer (2009)
Although there were no differences between training types on retention assessment, the immersive VR group showed better transfer, perceived enjoyment, motivation, and self-efficacy than the desktop VR group.	Makransky et al. (2019)
A generative learning strategy (GLS) implemented into immersive VR improves self-efficacy, retention, and transfer. The method of GLS enables the media efficacy (VR). Additionally, after attempting both media options, learners preferred VR.	Klingenberg et al. (2020)
A generative learning strategy implemented with VR was effective because it harnessed the affordances (presence and agency) that lead to engagement and allowed for reflective practice, which solidified the learner's schema of the concept.	Makransky et al. (2019)
The Cognitive Affective Model of Immersive Learning (CAMIL) is a synthesis of educational research that attempts to untangle the various outcomes of VR research through using instructional methods and media interactions to leverage the affordances provided by VR.	Makransky and Petersen (2021)

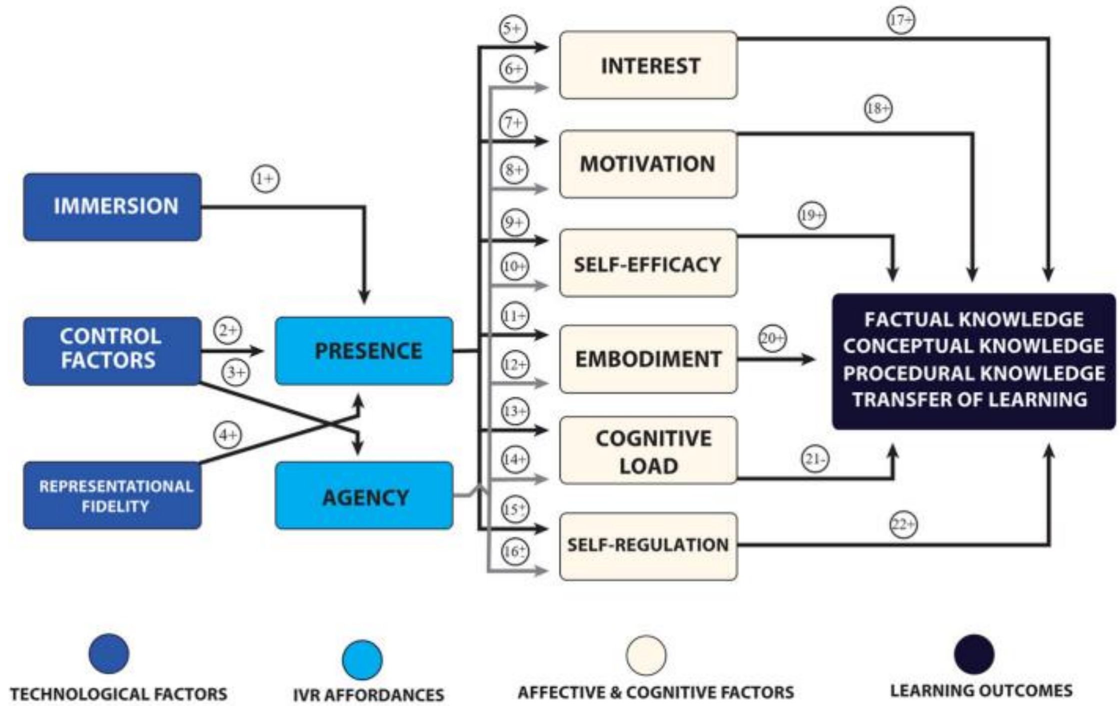
The Cognitive Affective Model of Immersive Learning

The Cognitive Affective Model of Immersive Learning (CAMIL) is a framework presented by Makransky and Petersen (2021), which attempts to tie together the many loose ends that can be observed in VR research to date. A dearth of research about the learning theories that support integration of VR has been identified which prompted the creation of an evidence-based theoretical framework about learning in immersive learning environments that can be used by researchers, practitioners, instructional designers, and anyone else with interest in VR learning applications (Radianti et al., 2020; Wu et al., 2020). "CAMIL provides a theory of change that describes how it is not the medium of IVR that causes more or less learning, but rather that the instructional method used in an IVR lesson will be specifically effective if it facilitates the unique affordances of the medium" (Makransky & Petersen, 2021, p. 940). CAMIL is applicable to present and future VR applications that are accessible through VR headsets (rather than cave VR or pc VR) because most recent research focuses on using these head-mounted gear due to the recent affordability of devices (Makransky & Petersen, 2021).

CAMIL makes some assertions that are based on previous data: 1) media relates with method and learning theories based on less immersive media generalize to immersive VR, but some methods are more relevant in that they are those that harness the affordances of the medium, 2) affordances in VR are presence and agency, 3) six cognitive/affective factors are relevant with VR learning, and 4) relationships among learning outcomes can be predicted (Makransky & Petersen, 2021). Figure 1 provides an overview of the CAMIL framework.

Figure 1

Overview of the CAMIL Framework



Note. (CAMIL) is a framework presented by Makransky and Petersen (2021), which attempts to tie together the many loose ends that can be observed in VR research to date.

The main affordances in VR are presence and agency. Presence is a feeling of "being there", which is an obvious feature of immersive virtual reality, and can be of three types: physical, social, and self. Presence is related to features of both user and media and can be thought of as having the following factors: extent of available sensory input, control over the environmental sensors, and degree that a user can modify the environment (Makransky & Petersen, 2021). They also state that sense of presence is influenced through the factors of immersion, control factors, and representational fidelity. Features of the VR environment design can then be harnessed to elicit this sense of presence in the learner. Agency, when a person feels in control of their actions, can also be built into the design of a virtual environment by allowing the user to have interactivity with the environment.

The six cognitive/affective factors identified by Makransky & Petersen as relevant with VR learning are interest, motivation, self-efficacy, embodiment, cognitive load, and self-regulation. Fostered by both a high level of presence and the agency of choice and control, interest occurs when attention is focused by certain stimuli with a positive affective reaction that leads to the person desiring to learn more. Motivation is supported through agency because the user perception is that they are in control of the environment, and achieving reaction helps enjoyment of the learner. A high sense of presence and agency lead a learner to have greater self-efficacy (through the strategy of allowing the learner to accomplish a task), which is when the learner believes in his or her ability to achieve success in mastering the learning material. Embodiment can be fostered through the high presence of VR and a sense of agency, allowing the user to perceive that their physical self and virtual self are related. Cognitive load, the amount of effort one must undertake to learn new concepts, is essential to consider when designing in VR and several studies have found evidence that VR can actually increase extraneous cognitive load if not designed with this factor in mind. Self-regulation can be fostered when reflective practices are used that allow a learner to go beyond the limits of their own cognitive load and to be able to successfully regulate their actions to be successful in achieving the learning goals, which can be lost to a learner because of the distractions that can be caused by high levels of presence and agency.

Relationships among learning outcomes can be predicted about the effectiveness of VR when learning factual, conceptual, and procedural knowledge and eliciting transfer of that knowledge (Makransky & Petersen, 2021). Factual knowledge, or knowledge of discrete content pieces such as vocabulary or basic facts, has been shown to have little benefit by being presented in VR so designing for this type of knowledge must be considered. Conceptual and declarative knowledge outcomes also have not gained evidence of effectiveness in using the VR environment. Procedural knowledge is when a learner engages in doing something – such as CPR or driving a car – and VR provides an excellent environment for learners to practice procedures to achieve mastery. Transfer of learning occurs when the learner is able to put themselves in different situations and still perform successfully, such as learning to drive a car and then driving a moving van. Researchers have found that learning transfer can effectively occur in both procedural and conceptual learning situations. All of these outcomes are greatly affected through the listed cognitive and affective factors, which are supplemented through presence and agency.

CAMIL is recommended to be used in research where specific affordances of agency and presence can be leveraged through the cognitive and affective factors to help generalize whether these interactions between media and methods can be examined to understand learning when using particular modalities, including but not limited to immersive VR. CAMIL is based on educational theories and associated research, but it's novelty inspires researchers to investigate the specifics within the model to add to the scientific database of knowledge.

Opportunities in CPR Training

A 2015 report (A Time to Act) prompted the American Heart Association (AHA) to develop a goal of having 20 million people trained in CPR and increasing the rate of CPR performance (Brown & Halperin, 2018). CPR training has two primary audiences - professional healthcare provider training and bystander training. For this study, bystander training was examined since the participants of this study are not healthcare professionals. Bystander CPR has the power to save hundreds of thousands of lives each year since 50 percent of cardiac arrests occur with other people around who are likely not healthcare professionals (Kuyt et al., 2021, p. 1). To effectively achieve this goal, CPR training should be undertaken by the general population as a public health initiative. Buckler et al. (2019) performed a study which measured self-reported confidence and self-efficacy in performing CPR when cardiac arrest occurs after training with VR, meaning that VR can engage the learner and foster confidence when combined with CPR training.

The Lowlands Saves Lives trial was completed as a special event during a music festival allowing people to learn CPR through a VR App. This study found evidence to support VR as “noninferior” to traditional training; supporting that VR learners demonstrated more accuracy with compression rate while traditional learners showed more accuracy regarding compression depth (Nas et al., 2020, p. 331). This study exemplifies the idea that training combined with another method, such as a music festival or other social event, can reach a much larger number of people since it is convenient to their routine.

A thorough analysis of publications performed by Kuyt et al. (2021) reveals a promising future for VR and augmented reality (AR) research. For a decade, publications about CPR using VR or AR have grown exponentially, resulting in their review of 17 studies in 2019 alone.

Opportunities in Virtual Reality

Several recent studies highlight VR's promising opportunities, with most authors stating the need for further research. In 2014, Kalyvioti and Mikropoulos (2014) performed a literature review about using virtual environments to assist struggling readers, indicating a promising future for the role of VR in clinical settings with responsible administration by appropriate professionals. Further studies with youth and adults are recommended in a "systematic, longitudinal, and larger-scale" manner (Kalyvioti & Mikropoulos, 2014). Oranç and Küntay (2019) published an article about early childhood learning with augmented reality (AR) applications, positing that the combination of reality and fantasy in a playful manner has a potential for children to learn and develop skills using evidence-based AR applications. They also argue that the recent development of mixed reality applications has led to the need for continuing multidisciplinary research to answer specific pedagogical questions about how children effectively learn different concepts and how developers should apply these ideas into their creations (Oranç & Küntay, 2019). Smith (2019) published an article giving a broad overview of types of VR, benefits, and disadvantages of immersive VR, and affordances provided. They concluded that there are gaps in the current knowledge of VR learning and the potential that VR offers gives a strong argument for the conduction of further studies to determine how and why it should be used in educational settings. Kaplan et al.

(2020) more recently completed a literature review which sparked recommendations for further research to analyze essential gaps in the field of mixed reality (XR) concerning differences between populations, specific technology usage meeting needs of trainees, and task designation (p. 10). Ventola (2019) is currently exploring the clinical applications of mixed reality applications in pharmacy environments, including the role of VR to teach clinicians, counsel patients, research visualization, and apply behavior modification (pp. 268-272). The past few years have blossomed with studies about VR in its many forms and the field is ripe for research in many areas. While numerous studies to date indicate that VR in countless clinical applications shows efficacy, several significant challenges in this research field include: 1. lack of well-designed studies, 2. small sample sizes, 3. usability issues, and 4. adverse side effects that may occur while using VR hardware. Thus, further research is needed about efficacy, advantages, and disadvantages (Ventola, 2019, pp. 272-274). Widespread adoption of VR cannot occur unless research studies are performed which validate that this technology is indeed useful and will bring benefit to educational practitioners.

Since VR is an emerging technology in higher education, several items are necessary to increase adoption and understand opportunities including a definition of critical terms and theories, development of action research that leads to a better understanding of the field, building of cross-disciplinary best practices, and development of evaluation both in technical use and attainment of learning outcomes (Radianti et al., 2020). The potential benefits of VR in education have yet to be fully realized, which indicates that research on the efficacy of VR as a learning modality would greatly benefit the scholarly community in the field of instructional systems design and technology.

Games and Simulations for Education

Educational, or serious games and simulations are becoming increasingly common in educational and training environments because they have defined goals, measurable outcomes, individualized feedback, and emotional appeal (Boller & Kapp, 2017). Games can gain attention and promote satisfaction through the use of game elements while they interactively challenge a player to meet a goal with a measurable outcome, work in an environment that has constraints in the form of rules, give corrective feedback, and elicit emotion (Boller & Kapp, 2017). These game elements contribute to feelings of motivation and engagement as the learner journeys through their own experience of learning as an agent of that learning experience. Games have significant power to motivate and include learners who otherwise might not engage in the material. One such example lies in a study of retail employees for 12 months which revealed heightened motivation and engagement in a gamified learning environment in comparison to a learning environment without game elements in which learners logged in more frequently, provided correct responses on assessments, and exhibited exploration behavior in the learning platform (Boller & Kapp, 2017).

Clark et al. performed a meta-analysis of game-based learning studies, constrained by type and time frame (randomized controlled trial or controlled quasi-experimental research designs between 2000-2012). This meta-analysis was published in 2016 with a nod to several previously published meta-analyses (Sitzmann, 2011; Vogel et al., 2006; Wouters et al., 2013). Results from these four meta-analyses support the theory that game-based learning is more effective than traditional instruction, with game design playing a crucial role rather than simply being the medium of instruction (Clark et al., 2016, p. 116). Bai et al. (2020) performed a more recent meta-analysis and found that individuals like the idea that games generate enthusiasm and provide feedback, however, games can also have adverse effects such as dissatisfaction with intangible rewards and feelings of insecurity, anxiety, or jealousy. Examination of these meta-analyses indicates that serious games and simulations are effective in learning environments among students. These listed studies highlight positive outcomes for learning in game-based experiences. Games are typically thought of as experiences in which people engage for entertainment and relaxation. These same elements that make games satisfying can apply to education with similar results. Notably, learners who are actively involved with the learning goals and outcomes are more successful in meeting said goals. Results of game elements and strategies support the study of games for learning in immersive virtual reality.

Immersive VR with spatial navigation and manipulation was explored in another study as compared to traditional word-word paired association strategies in learning Chinese vocabulary among 64 native English speakers at Pennsylvania State University, measured by cognitive pre and posttests, which resulted in significance in learning context effects for less successful learners but had little or no impact for successful learners (Legault et al., 2019). This study points to the use of different modalities and strategies for different types of learners (as seen in this study between successful versus unsuccessful learners), thus future studies by these researchers might include more comparisons among learning conditions to measure the efficacy of learning vocabulary in a second language (Legault et al., 2019, p. 23).

A study using the HTC Vive VR system among undergraduate students at the University of California investigated the effect of sensorimotor interaction and observation in learning words in a three-part experiment (Gordon et al., 2019). This research focuses on how our bodies and interactions with environments interact with learning. Although this research focuses on VR, alternative interactive computer technologies should also be examined, including a study of augmented reality (AR) flashcards which examined the difference in recall of vocabulary when learning through the AR flashcards as measured with pre and post-tests, compared with paper flashcards, and also researching teacher feedback about the use of AR flashcards (Chen & Chan, 2019). A *t*-test indicated a significant positive difference in learning with the AR flash cards but a significant positive difference when using traditional paper flash cards. However, the difference between the two groups had no significance, indicating that there is no advantage in using one modality over the other (Chen & Chan, 2019). The teachers listed several benefits and disadvantages of using the AR flashcards but were optimistic about integrating them into the curriculum with other appropriate teaching strategies (Chen & Chan, 2019). More research with a larger population of students is indicated and a method to measure enjoyment and satisfaction of the learning activities (Chen & Chan, 2019).

Additionally, Pedroli et al. (2017) give a call to action for learners to have the opportunity to experience learning in an environment other than traditional paper and pen methods (which are not usually fun or engaging); thus, a study was conducted using Kinect to complete tasks in a virtual environment using NeuroVirtual 3D software. Results were favorable in several areas, indicating that this treatment helps learn application design for people with dyslexia (Pedroli et al., 2017, p. 4). This study had a tiny pool of participants (n=10), so further research would be helpful to gain a better understanding of the topic (Pedroli et al., 2017, p. 5). Melchor-Couto (2019) discussed virtual worlds in the framework of learning a foreign language, highlighting that VR can increase engagement, reduce anxiety through anonymity, and provide a more authentic environment. Some disadvantages include a possible low rate of adoption by teachers, technical challenges, and the loss of non-verbal human communication which can assist in learning a new language (Melchor-Couto, 2019, pp. 35-36). Moving forward, especially after the recent global health pandemic, these challenges are lessening and technology adoption is rising. The author leaves us with this quote: “Only time will tell if they consolidate as mainstream educational tools or if they remain an interesting option for the most adventurous practitioners" (Melchor-Couto, 2019, p. 38). As we move into the future, there is no doubt that the realm of education will adopt many more educational tools and we only have to pinpoint which are the best options for our students.

Schouten et al. (2017) described a virtual learning environment called “Virtual Environment to Support the Societal Participation Education of Low-Literates" (VESSEL) which was created to benefit people with low literacy by helping to develop the cognitive, affective, and social skills that are deemed necessary to be a participant in society. The system framework design is discussed in detail, which states that three phases of foundation, specification, and evaluation must be looked at to effectively design the system (Schouten et al., 2017, pp. 682-683). The specifications are thoroughly outlined in this paper which sets up the plan to move forward with creating the assistive tools using virtual learning environments, prototyping, and testing for efficacy (Schouten et al., 2017, p. 694). This method of systems analysis helps look at technology tools that are to be adopted.

Wang et al. (2017) explored the possibilities of learning English as a second language in China through the use of a virtual environment named “Virtual Immersive Language Learning and Gaming Environment," or VILLAGE, which was designed to be an immersive experience that enhanced learner presence through the use of learning artifacts. The study measured presence in a variety of immersive situations that included different aspects such as the use or lack of use of the learning artifact combinations, also measuring the tendency of the learner to immerse in an activity. A single factor independent measures design was used with 80 randomly selected students from a language school in China, and the results indicated that the use of learning artifacts increased presence (Wang et al., 2017). Further studies are recommended to measure other artifacts and whether language can be naturalized into the cultural context when using virtual environments (Wang et al., 2017, p. 448).

Virtual Reality Implementation Challenges

Immersive learning strategies have augmented knowledge and skills learning for many decades, as described by Carl Blyth (2018), who discussed immersive environments for language learning in an article that examined the historical significance of the topic, defined challenges, and finally recommended research priorities to guide educators precisely in the coming years. The concern about artificial intelligence in education is discussed, urging teachers to position themselves as cultural context experts as well as handle disruptive technology, stating “change is inevitable and good teachers will always find ways to adapt” (Blyth, 2018, p. 230) because, in the future, immersive technology will challenge the idea that context cannot be taught through computing technology by making experiential immersive learning possible. Virtual Reality is not yet widespread in education due to various issues. Although VR can personalize learning, increase intrinsic motivation and enjoyment, and contribute to a deep learning environment, it has limitations. These limitations include: 1. overhead costs, 2. input and output problems such as usability issues and motion sickness, 3. embodiment and presence such problems as the comfort of VR, 4. ethical issues, and 5. lack of perceived usefulness (Kavanagh et al., 2017; Pan & Hamilton, 2018; Ventola, 2019). Furthermore, the pandemic outbreak of COVID-19 in the spring of 2020 has presented a whole new plethora of challenges, including sanitization and access to devices. Conversely, the field of VR has found new opportunities since affordances have been made that can allow learners access to situations that otherwise are inaccessible, such as some healthcare or criminal justice experiences. While several roadblocks impede VR adoption, developers, researchers, and practitioners have optimism that these challenges can be overcome. VR can find a place in contemporary education.

Research Opportunities in Virtual Reality

The recent releases of standalone VR headsets such as the HTC Vive in 2015, the Oculus Go in 2018, the Oculus Quest in 2019, and the most recent Oculus Quest 2 in 2020 have significantly advanced the opportunities for virtual reality use. Prior VR systems have been clunky and difficult to use since they require tethering to a PC, which has to have the appropriate specifications to allow the VR software to work correctly. Most home personal computers are not outfitted with these kinds of features, so in addition to the VR hardware, consumers have been required to purchase or update computers as well. With the recent standalone headsets, we have reached a tipping point regarding technological breakthroughs and can only now leverage the affordances of virtual reality in education more vastly. As VR becomes more affordable and the technology continually improves, it is an excellent possibility that the educational sector will start to see a greater interest in using this type of learning modality. To that effect, efficacy research with positive learning outcomes will be vital to VR developers and educators as we move forward, setting a precedent for future educators who want to effectively implement VR in their teaching. Steffen et al. (2019) lay out a theoretical framework that states certain aspects of VR and AR are essential, including examination of user goals, generalization of implementations, and comparison of AR and VR to physical reality, and concludes that users adopt alternate realities when the affordances offer more benefit than actual reality. Some examples of these include situations where hazards are present, actual environments are unavailable, or people must travel great distances to perform the skills. Kharin et al. (2017) also recommend using a framework that can help direct the potential game-like environment into appropriate educational activities. The intentional development of VR applications must be adequately matched with educational goals to leverage the power of VR to be most effective in educational systems.

Summary of Literature Review

Several studies have been examined here, which support further research about immersive learning in VR. Student motivation, agency, and engagement are products of immersive learning, and these studies support the use of immersive technology in teaching and learning. The focus of this study is to examine the efficacy and learner experience of using VR to support learning CPR in a classroom setting. Finally, the affordances that can be harnessed in VR are supported because VR provides an opportunity to learn and practice skills in an environment that is not easily mimicked in a classroom setting – which, for the purposes of this study, is the simulation of a person experiencing a sudden cardiac arrest and needing to be saved by somebody performing CPR. As VR matures and integrates into society, researchers must take on these and other upcoming issues. There is great variety in outcomes regarding VR across the literature, and to help untangle the competing ideas, Makransky et al. (2021) have proposed the framework of CAMIL, which will be greatly helpful in this investigation since it relies on effective pedagogy strategic methods that are presented via instructional media that take advantage of the affordances that are provided by the immersive learning experience. CAMIL is the framework that allows all of these aforementioned theories to merge together into creation and use of VR as an effective and engaging instructional modality. Table 3 summarizes applicable frameworks gathered from the literature that are current in the field of immersive virtual reality research.

Table 3

Conceptual and Theoretical Framework Supporting Immersive Learning

Theory	**Evidence**	**Description**
Constructivism	(Buttussi et al., 2020)	People learn through direct experience and knowledge builds upon prior learning.
Development Learning Theory	(Buttussi et al., 2020; Kaplan et al., 2020)	People learn best in contextual situations that most closely mimic the real-world environment in which the skills and knowledge must be applied.

(continued)

Theory	Evidence	Description
Theory of Deliberate Practice	(McDonald et al., 2021)	Specific skills are practiced with guidance and feedback to obtain mastery of those skills.
Self-efficacy	(Buttussi et al., 2020; Moon & Hyun, 2019)	Self-efficacy occurs when a participant feels confident about their performance of knowledge or skills. Self-efficacy can be assessed using a Likert scale survey instrument.
Affordances	(Salzman et al., 1999; Steffen et al., 2019)	People use AR and VR when activities become possible that could not otherwise be afforded easily or conveniently in physical reality.
Cognitive Load Theory	(Araiza-Alba et al., 2021)	People learn best when attention is focused primarily on the task at hand, not allowing other distractions to interfere with working memory.
Multimedia Instruction	(Mayer, 2009)	"People learn better from words and pictures than from words alone."
CAMIL	(Makransky & Petersen, 2021)	Instructional media interacts with methods that leverage affordances to positively affect learning outcomes.

These theories and frameworks are important because they work together to help explain how people learn – and thus, how they can learn with VR. The CAMIL framework marries several of these theories together through the idea that media interacts with methods while leveraging the affordances of presence and agency so that learning outcomes can be achieved.

CHAPTER III

Methodology

Overview

This study intended to find evidence that provided guidance to recommend or not recommend using a specific supplemental virtual reality application deployed on the Oculus Go platform in learning CPR skills. Multiple analysis methods are selected because it allows researchers to look at qualitative data such as learner perception and satisfaction and analysis of assessment scores. Using both types of data has the power to illuminate information that can easily be missed or clouded when performing a smaller study. This section outlines the method and design, participants, instruments, procedures, and data collection and analysis. To review, the research questions and hypotheses for this study are restated.

Research Questions:

RQ1: What effect does the application of Virtual Reality as a supplement to traditional procedural training have on adult learning outcomes?

SubRQ1: How does the addition of a supplemental virtual reality simulation affect adult performance between groups in a recertification Cardio Pulmonary Resuscitation (CPR) course as measured by the change in scores between an exit test and subsequent post-test comparison using the Basic Life Support certification exam?

RQ2: Does the additional modality of VR affect self-efficacy for adults in a CPR recertification course?

SubRQ2: When surveyed for self-efficacy, is there a significant difference between pre, post, and follow-up change of self-efficacy scores between groups?

Hypotheses:

Supplemental virtual reality simulation will improve CPR knowledge and skills performance in adult CPR recertification participants as measured by a test and post-test comparison as measured using the American Heart Association Basic Life Support certification exam.

Participants in the experimental group will report greater self-efficacy when surveyed two weeks after the CPR VR experience.

Research Method

This study aimed to measure the efficacy and experiential aspect of VR in CPR skills acquisition, which is best explored through a quasi-experimental case study. This study was conducted by adding a VR simulation, “Saving Lives”, into a curriculum that is already used to recertify CPR through the American Heart Association. In this pre-post experimental design, participants in the intervention group had the opportunity to practice CPR procedural knowledge and skills in the “Savings Lives” VR simulation before completing their certification assessments, whereas the control group participants only participated in the standard learning environment.

Research Design

Cohen et al. (2011) highlight mixed-method studies, which combine elements of both qualitative and quantitative methods, as an effective way to study a phenomenon because they can be “mutually illuminating” (p. 24). These advantages of mixed-methods include obtaining better data accuracy, mitigating weaknesses of single research approaches, allowing for scaffolding, and assisting in data sampling (p. 22). The data collected in the quasi-experimental design (measuring learning with tests and surveys administered at specific time points) can be augmented and further analyzed with experiential survey information. Surveys collect qualitative information from participants about variables such as delight while using VR, satisfaction, and challenges such as motion sickness or discomfort using VR. The qualitative nature of obtaining survey and observation data lent an essential depth of knowledge to the experiential aspect of immersive learning, which might not be evident when examining quantitative data alone.

A case study method explored both the qualitative and quantitative quasi-experimental data collected in this study. Case studies are appropriate for situations in which many variables can have an effect, in "real" situations, when multiple data types are collected, when the focus is narrow, when the scope is bounded, and when the research seeks to understand the topic in depth (Cohen et al., 2011; Creswell & Poth, 2018). Students in the intervention group completed the simulation "Saving Lives" in virtual reality on the Oculus Go. The control group participated in a traditional setting with no VR intervention. The comparison helped determine whether the immersive learning environment has any effect on learning knowledge and skills that are considered essential when learning layperson CPR as measured by a standardized assessment (Appendix A). Recent educational research has been conducted in immersive learning using case study methodologies, which allow researchers to examine modalities in great detail (Buttussi et al., 2020; Cheng & Tsai, 2019; Pavlik, 2017; Yildirim et al., 2018). The research conducted about learning knowledge and skills in immersive VR, explicitly using the "Saving Lives" VR simulation, fits into this research method nicely. While this plan may have changed due to the current global pandemic of COVID-19, the study was planned for the Spring of 2022, pending committee and IRB approval. Participants completed the "Saving Lives" simulation in randomly assigned groups on a borrowed Oculus Go headset. Pre and post-tests measured the CPR knowledge of the students to determine the efficacy of immersive VR as a learning modality, which aligns directly with the research questions that seek to measure the learning of indicated vocabulary and skills with the assessments. The BLS Examination was administered immediately after training completion (TP2) and two weeks after the completion of the simulation (TP3). A self-efficacy survey was issued before training (TP1), after training (TP2), and two weeks after training (TP3).

Participants

The CPR instructor can host eight students at a time per class. Thus, an attempt was made to recruit sixteen faculty and staff members to participate in this study, aligning with the sampling strategy commonly used in case studies described as "convenience sampling" (Cohen et al., 2011, pp. 155-156). Students were randomly assigned to either an intervention group or a control group. The intervention group used the "Saving Lives" simulation through the Oculus Go VR gaming platform, and the control group participated in traditional learning and study methods. Demographic information was collected from the participants through a validated self-efficacy survey with added questions about occupation, age, education level, prior CPR certification, and prior VR experience. All participants benefited by achieving CPR certification through the college, and the college also benefited since more people were effectively trained in CPR.

Approval was sought from the school's Institutional Research Board and the Sam Houston State University Institutional Review Board before research began. The ethics of research must always be considered when working with human subjects. The first step was to establish informed consent. This documentation informed participants of the procedures and purposes, identified associated risks and benefits, posed alternatives that could be pursued, offered to answer questions, and provided an exit strategy that allowed the participant to discontinue their participation at any time (Cohen et al., 2011, p. 78). This information is outlined in the project description document in Appendix E. Data obtained from the assessments and surveys were de-identified before analysis.

Saving Lives Simulation

The "Saving Lives" simulation is available via Oculus Go in VR or as a two-dimensional mobile app developed by the Incite VR company. Incite VR specializes in providing immersive learning solutions for healthcare and enterprise safety in professional development and higher education settings geared toward making learning engaging, scalable, persistent, and long-lasting.

The "Saving Lives" simulation is activated by clicking the "layperson mode" button, which automatically starts a timer and begins with a scene of a person lying down. In the near distance is a crowd of people. There is a button that reads "confirm scene safety" and a CPR mask with a circle around the person's chest. The user must decide what to do first, with the correct choice being to confirm scene safety which allows the user to tell someone to call 911 and get someone to find an Automated External Defibrillator (AED), and then begin CPR. Figures 2 and 3 display screenshots of the app.

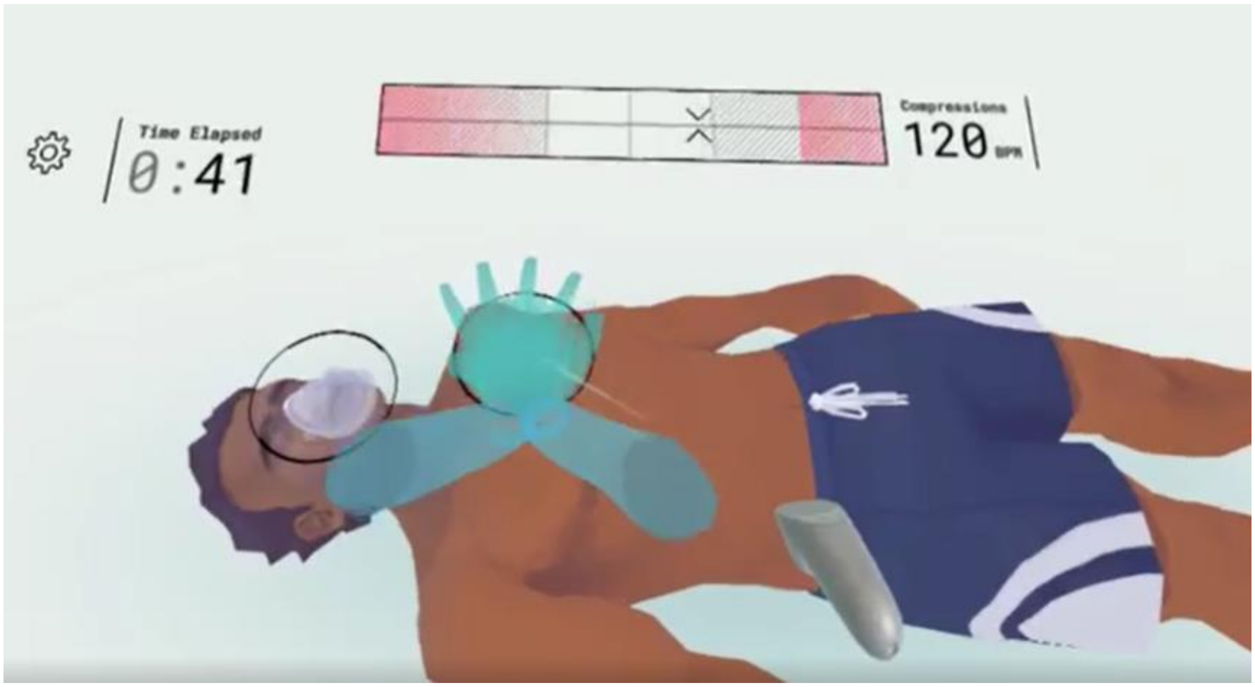
Figure 2

Saving Lives: Assessing the Scene

The next step lets the user check for the patient's responsiveness and they are then notified that the patient is unresponsive. The user then performs CPR, attempting compressions at a rate of 100-120 per minute and giving a breath every six seconds. Compressions and breathing actions are achieved by pointing and clicking the controller at the circles. A slider shows the rate of compressions and coaches if the user is compressing too fast or too slow during these actions. The “time off chest” is also measured and displayed.

Figure 3

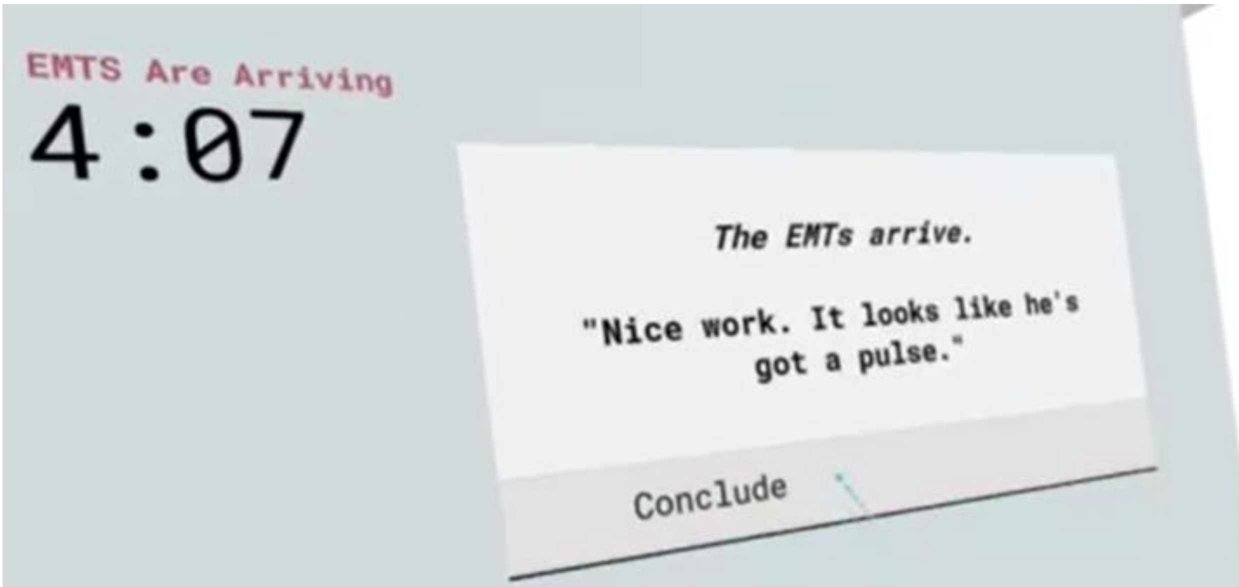
Saving Lives: Performing Chest Compressions in VR



Once the AED arrives, prompts guide the user to open the AED unit, power it on, connect pads to the patient, analyze the patient to advise a shock or not, clear the patient, administer the electric shock, and then resume compressions. After the AED is used, the user goes back to CPR processes of circulation, airway, and breathing for two minutes, and the patient is analyzed again for the need for the AED. This cycles until the ambulance arrives, sirens wailing. At the end of the simulation, the patient either appears responsive, and the user is coached to place in the recovery position or has turned blue (indicating not breathing). In either case, the EMTs arrive and take over. Feedback is given about the patient to the user, such as in Figure 4.

Figure 4

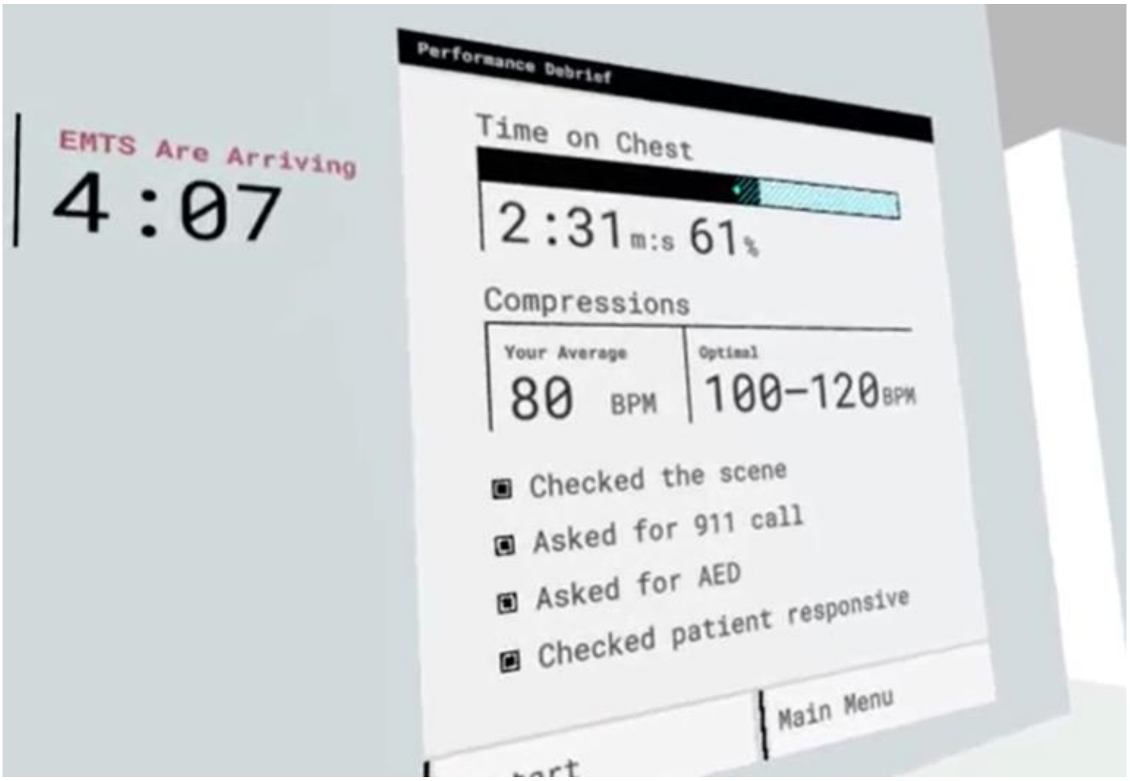
Saving Lives: Image of Feedback



After the “Saving Lives” simulation concludes, the user is debriefed (Figure 5) and receives feedback about their performance in several areas: time on chest and compression average BPM compared to optimal BPM, as well as whether they completed the actions of checking the scene, asking someone to call 911, asking for an AED, and checking patient responsiveness.

Figure 5

Saving Lives: Performance Debrief



The user can attempt the sequence again or exit to the main menu.

Instruments

The standard American Heart Association Basic Life Support Exam (Appendix A) was administered immediately after and two weeks after training to all groups of participants to determine if there is a difference in scores using the immersive VR simulation versus traditional methods. A self-efficacy instrument (Appendix B) was used to survey students before training, after training, and two weeks after training to measure self-efficacy data on a Likert scale. The self-efficacy survey collected demographic and qualitative information with open-ended questions about delight, satisfaction, and other pertinent data elements. These instruments were pilot tested by the researcher before actual administration, which is recommended to ensure that instructions are clear, the wording is appropriate, and the time frame is reasonable (Fink, 2017, p. 24).

Procedures

Faculty and staff were asked if they were interested in participating in this research study which occurred over the course of two meetings, two weeks apart. The first meeting included the CPR training and certification using the BLS Exam and the self-efficacy before and after training as well as demographic instruments. The second meeting involved administering the knowledge test and self-efficacy survey again. Data were collected during specific points in the research; Time Point 1 (TP1) occurred before certification training, Time Point 2 (TP2) occurred immediately following certification training, and Time Point 3 (TP3) occurred approximately 2 weeks after the initial training period. Before specific participants were asked to commit to the research study formally, approval from the Institutional Research Boards was obtained. Additionally, informed consent documents were dispersed to read, sign, and were collected before the training begins. The participants were randomly assigned to groups to participate in the “Saving Lives” simulation group or the traditional group. The students in the intervention group were each provided with an Oculus Go device that they used to practice skills during the class. A brief tutorial about using the Oculus Go oriented users to the device. These steps were provided to them via a document and instructional video with detailed instructions that include using and adjusting the headset, using the controller, navigating the interface, opening the CPR app “Saving Lives,” and performing the steps within the app. Personal assistance was made available to participants who needed it. Before training began, participants completed the demographic and self-efficacy surveys (Appendices B & C).

After the training, students completed the BLS Exam and self-efficacy survey and intervention group participants had the opportunity to provide additional feedback to the researcher(s) in the VR survey (Appendix D). Another BLS exam and self-efficacy survey were administered approximately two weeks after the course completion to measure long-lasting learning.

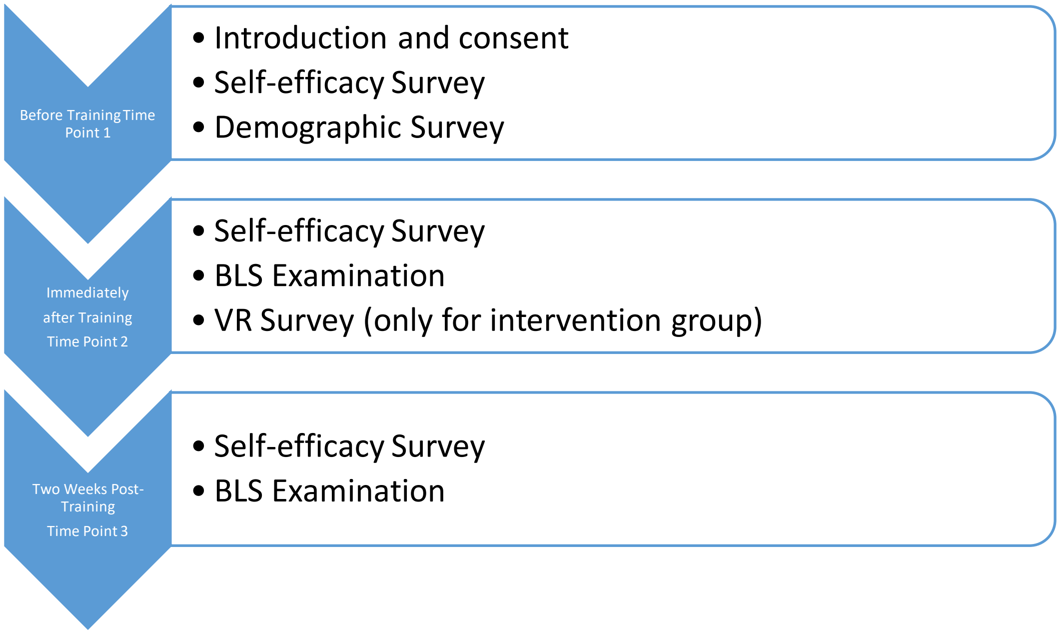
Since it is vital to ensure that the devices are clean and disinfected, the Oculus Go devices and controllers were cleaned with disinfecting wipes before and after each use. In addition, the devices were disinfected and rested (meaning they sit without being used) between uses according to current CDC guidelines.

Data Collection

Data were collected via tests and surveys. As seen in Appendix A, the test and post-test were identical and measure basic life support knowledge. Surveys collected data about basic demographics (Appendix C), prior CPR and VR experience (Appendix D), and self-efficacy (Appendix B). Figure 6 presents the data collection procedure.

Figure 6

Procedural Steps for Data Collection

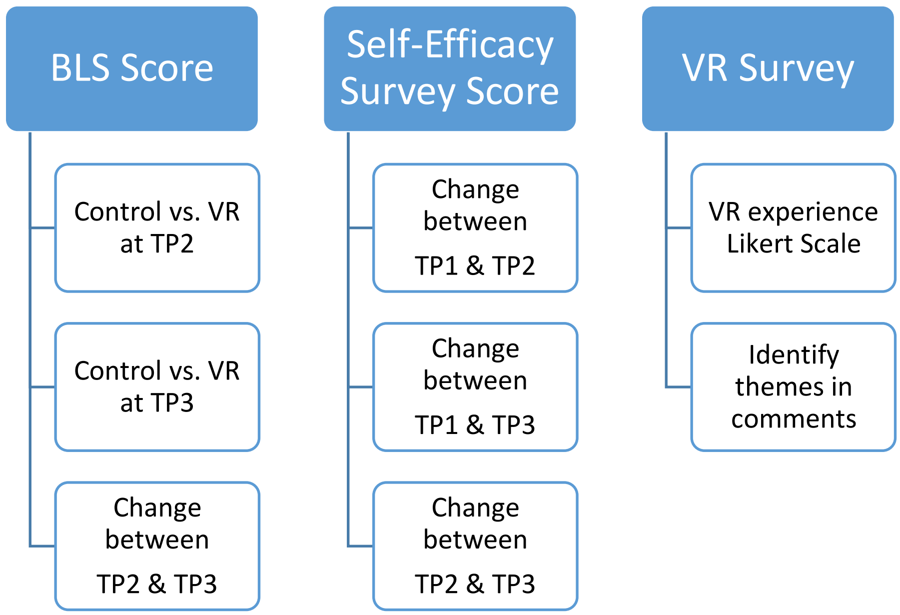


Data Analysis

Analysis of the collected data was completed using IBM SPSS software, first examining descriptive statistics and then performing appropriate statistical tests to determine if there was significance in the differences between the groups (Field, 2018). A *t*-test is indicated when comparing two means based on either dependent or independent data (Field, 2018), so basic vocabulary and skills mastery data collected in the BLS Exam could be analyzed using a *t*-test for each variable. Figure 7 illustrates the measures that were analyzed.

Figure 7

Graphical Representation of Data Points



The *t*-test assumptions include affirmation of independent observations, interval or ratio types of the dependent variable, and lack of outliers (Field, 2018). Since these data are linear, all of the assumptions of the general linear model apply along with additional testing for "independence of covariate and treatment effect and homogeneity of regression slopes" (Field, 2018, p. 598). Qualitative data was compared across survey responses to identify themes and commonalities among the collected data, which can inform the assertions written by the researcher that was informed by the study (Creswell & Poth, 2018). Assertions are the outcomes of qualitative data that researchers can make after carefully examining the data. This study offered recommendations about the efficacy of using immersive virtual reality to learn CPR skills. Additionally, qualitative information about emotional experiences and student satisfaction during immersive learning was identified in the study. Qualitative data was coded into main themes to enlighten researchers about possible effects of virtual reality, which may or may not be presented when analyzing the BLS Exam assessment scores.

Summary of Methodology

Chapter III was created to provide detailed information as to the quasi-experimental research method, describe the planned research design, discuss selection of participants, describe the "Saving Lives" VR simulation, explain the data collection instruments, detail procedures, and describe data collection and analysis. A quasi-experimental research design was used that could compare assessments that were administered at different times during the study which aimed to add to the literature about the efficacy of a VR simulation when used in conjunction with a CPR re-certification course. The research design measured BLS exam scores and self-efficacy in a quantitative manner as well as the qualitative information about satisfaction and pleasure while using the VR simulation. Participants were recruited by email from a small university to participate in the CPR re-certification course. The simulation used was titled "Saving Lives" and was available on the Oculus Go headset. Data were collected using the standard American Heart Association BLS exam, a modified self-efficacy survey, and a survey to assess participant satisfaction with the virtual reality experience. The next chapter will examine methodology in context, which aims to lend transparency to the process in entirety.

CHAPTER IV

Methodology in Context

Chapter Overview

Chapter III housed the initial intent for methodology for this study. As time will often reveal many changes, this chapter will describe the actual procedures used to solicit and select participants, prepare and apply for Institutional Research Board Approval, issues that unexpectedly occurred, data collection, and some follow up information pertinent to the study.

Methodology in Context

Good research allows a path to be created which can assist future researchers in the field to replicate research practices, which leads to a more robust and accurate literature database (Onwuegbuzie et al., 2017). Transparency in research adds to the scientific literature to allow an iterative process that researchers can leverage to make greater strides in the field. Sometimes research in practice reveals elements that had not been considered when in the planning phase, thus a chapter dedicated to how the research process actually was deployed can be of great benefit to future researchers in the topic. Even this project underwent many iterations before it was successfully implemented and these false starts and learning opportunities should be highlighted.

Institutional Review Board Process

Before an attempt is made to file for Institutional Review Board (IRB) approval, the proposal must be prepared and defended to the dissertation committee. The project proposal was approved on March 7, 2022 by the committee with only minor considerations for moving forward with the research process. Before I attempted to submit my IRB application, I met with my chair to go over the details and she helped me with any questions that I had. Since the study was to be completed by a Sam Houston State University student researcher, but was being conducted on the campus of another university, IRB approval had to be obtained from both institutions. An attempt was made to have the participating institution allow the primary institution to make overall approval of the study using an IRB Authorization Agreement (IAA) form, but turned out to be impossible because that would require both institutions to be federally registered with the Department of Health and Human Services (DHHS). Since the school where the study was to be held was not registered with DHHS, a second IRB application process was required.

The expedited SHSU IRB application was initiated in the Cayuse platform on March 9, 2022 and returned for an edit on March 16, 2022 due to an error in the title of my chair. It was resubmitted on March 17, 2022 after requested edits were made. The IRB analyst and subsequently the IRB reviewer asked for some clarifications and it was then resubmitted again on March 28, 2022. The final application was approved on March 29, 2022. Edits included 1) clarified the CPR course instructor role and her access to the data and whether she needed to be added as an "unaffiliated person", 2) uploaded the instructional sheet for how to use the VR headset along with the instructional video, 3) changed "faculty and staff" to "students/participants", 4) verified that email systems used are end-to-end encrypted, 5) clarified how to get access to the email list to recruit participants, 6) stated how the email recruitment would happen, 7) defined plan to address what to do if someone got dizzy or nauseated, and 8) defined how the signed consent forms would be secured.

Before I applied for IRB approval, I emailed the provost of the college to obtain approval to perform the study and uploaded that approval letter into the Cayuse system. The NC Wesleyan College IRB process was initiated by sending the following documents via email to the IRB Chair on March 15, 2022: 1) Form B-1: Research Review Status Self-Report, 2) Form B-3: Checklist for Research Qualifying for Expedited Review with Guidelines for Protocol Preparation, 3) Consent Form, 4) Dissertation Proposal, and 5) Provost approval letter. The participating college IRB application was approved with no requested revisions on March 22, 2022.

Participant Recruitment and Selection

Once IRB approvals were obtained, I consulted with the CPR instructor to pick potential dates for the classes to be held. An email was sent to faculty, staff, and adjunct faculty at the institution to establish interest on March 31, 2022 and my dissertation chair was copied. I received several interested parties who were unable to participate due to the fact the they had not been recently CPR certified. This left 13 possible participants, who were sent four date selections on a Doodle poll. Two dates were selected and participants were assigned to classes based on their indicated availability. The first date actually had to be rescheduled due to an important unexpected schedule conflict on the part of the CPR instructor. Once the dates were determined, participants were informed of the dates and location twice (one initial email and one reminder). Since I was not completely familiar with how the CPR class was structured, the first group performed as the control group and the second group was the intervention group. This allowed me to observe the class and determine how to best add the VR headset enhancement. Two participants were unable to participate due to scheduling issues, so the final count was 11 - 4 people in the control group and 7 in the intervention group.

Since this study asked participants to complete the BLS and self-efficacy surveys approximately 2 weeks after the initial class, another Doodle poll was sent to determine availability and participants were emailed to let them know when and where they should report back for the follow up meeting.

Preparing for the CPR Classes

To get ready for the classes, I printed documents including the BLS exams, the self-efficacy survey, the VR survey, rosters, answer key for scoring, and the consent forms. I also cleaned, charged, checked controller batteries, and installed via Sidequest software the “Saving Lives” software on all of the Oculus Go headsets. I obtained wrist bracelets and patches for participants who may need them for nausea. I made sure that we had pens, extra batteries, whiteboard markers, and headset chargers.

Conducting the Classes

The first CPR class occurred at 4 p.m. on May 2, 2022 in a classroom housed in the campus library and included four participants. Before class began, each participant completed the informed consent paperwork and the pre-training self-efficacy survey instrument. These participants already knew each other, so introductions were not necessary. The instructor taught adult, child, and infant CPR to the class and then performed assessments by observing performance with the CPR mannequins and administering the written exam. Along with the written BLS exam, participants also completed a self-efficacy survey again. She scored and gave feedback to each participant about the exam and let them know they would receive their CPR certification cards via email.

The second class was held on Thursday, May 5 at 1 p.m. and was located in the same classroom as the first class. Before class began, each participant completed the informed consent paperwork and the pre-training self-efficacy survey instrument. These participants did not know each other, so introductions were made. The instructor taught adult, child, and infant CPR to the class and then observed the participants to assess proper CPR technique on the mannequins. Once the content and observations were made, each participant was provided an Oculus Go headset with printed instructions (APPENDIX H) on how to use the headset and access the “Saving Lives” simulation. A QR code also linked to a video if the user wished to watch a short tutorial, but they were excited to try out the headsets so nobody took advantage of the tutorial. A few of the participants needed help, but most were able to access the tutorial with the instructions. The tutorial is not much longer than 5 minutes to complete one round, so the participants were advised to practice as much as they wanted to before they completed the BLS exam. None of the participants complained of nausea or sickness, so the bands and patches remained unused. After the CPR simulation was completed, the written exam and self-efficacy survey were administered. Several of the participants had questions about some of the exam questions and the instructor helped to clarify those particular questions. The instructor scored and gave feedback to each participant about the exam and let them know they would receive their CPR certification cards via email.

The Follow-Up Meetings

After the initial classes, participants were sent an email with a Doodle poll with several dates that could be chosen in which they could come in for the follow up meeting in which they would take the BLS exam and self-efficacy survey another time. Four meetings were scheduled in the campus Teaching and Learning Center: May 18, 19, 23, and 26. Participants were encouraged to choose which date and time was most convenient for them. The first meeting coincided with construction work happening in the building and they literally were drilling through the wall in the room next door. I went over and asked them if they could stop the noise for a few minutes, and they took the opportunity to take a break. After that initial hiccup, the rest of the meetings went smoothly. For all participants, I scored their exams and shared the results with them individually.

Data Consolidation

After the classes, there were several papers with data that needed to be input into a spreadsheet to enable analysis and I had to obtain the final BLS scores from the CPR instructor since is required to send the exams to the AHA in order for the participants to receive their certification cards via email. I assigned aliases for each participant, created tabs for each data point, and entered all of the data into the sheet. After this was complete, I locked the documents in a cabinet in my office per IRB guidelines. The spreadsheet contained tabs for 1) the BLS exam scores with timepoint, 2) the self-efficacy scores with timepoint, 3) the demographic surveys, and 4) the VR survey. To ensure privacy and confidentiality, the participant names are not contained in this data spreadsheet.

Participant Reactions to the Study

Overall, the participants were excited that they were able to both help me with my study and renew their CPR certifications. The CPR instructor was happy to get more people certified because, as a nurse educator, she believes in spreading knowledge and skills that can save lives. She was also glad to be able to connect in this way with faculty colleagues. Some conversations were also initiated in how we could further this service to faculty and staff and the college will likely pursue additional CPR certification opportunities in fall of 2022. The participants found the training very valuable and appreciated the enthusiasm of the instructor.

Summary of Methodology in Context

Chapter IV highlighted contextual considerations including IRB process, recruitment of participants, preparation of classes, conduction of the classes, follow-up meetings, data consolidation and security, and reactions from participants. Chapter V will present the quantitative and qualitative results from this study.

CHAPTER V

Results

Introduction

In Chapter V, I present my data analysis. I explain the strategy used to analyze the data collected, present demographic information, restate the research questions and hypotheses, present the BLS results analysis, present the self-efficacy analysis, share the VR survey results, and discuss emerging themes.

Data Analysis Strategy

Basic Life Support Exam scores were examined with SPSS software using independent *t*-tests to compare scores between groups immediately after training, two weeks after training, and the change between the groups. Self-efficacy average scores were also examined using *t*-tests to compare time points. Qualitative data in the form of comments was examined to determine themes among the data.

Demographic and CPR Experience Information

The participants in this study responded to survey questions for demographic purposes and information about experience with CPR certification. Results are consolidated after each question in Table 4.

Table 4

Demographic and CPR Experience Results

Survey Question	Results
Are you currently CPR certified?	Two participants were current and nine were not current on CPR certification.
When was your last CPR training and certification completed?	Five participants were last certified in the past 2-3 years and six were last certified over 5 years ago.

Continued

Survey Question	Results
How long have you been CPR certified (in years)?	Length of certification ranged from 2 to 29 years.
What is your date of birth?	Participants ranged in age from 29-71 years old. The average age was 48 years old.
What is your occupation?	All participants are educational professionals at a small liberal arts university in a rural area of North Carolina.
Why are you renewing CPR certification?	Renewal reasons included desire for CPR certification, need for work, being a helpful person, responsible community behavior, personal knowledge, good skill to know in the library, and helping with the doctoral dissertation study.

Research Questions

RQ1: What effect does the application of Virtual Reality as a supplement to traditional procedural training have on adult learning outcomes?

SubRQ1: How does the addition of a supplemental virtual reality simulation affect adult performance between groups in a recertification Cardiopulmonary Resuscitation (CPR) course as measured by the change in scores between an exit test and subsequent post-test comparison using the Basic Life Support certification exam?

RQ2: Does the additional modality of VR affect self-efficacy for adults in a CPR recertification course?

SubRQ2: When surveyed for self-efficacy, is there a significant difference between pre, post, and follow-up change of self-efficacy scores between groups?

BLS Exam Results

The results from the BLS exam scores aim to answer research question 1 and sub research question 1 by measuring the scores earned on the BLS exam at two points in time – immediately after training and approximately 2 weeks after training. Table 5 presents the results from the different time points along with the calculated change and the data is stratified by group. Figure 8 displays the averages of scores by group and time of exam. Both groups displayed a slight decrease in score over the two time periods.

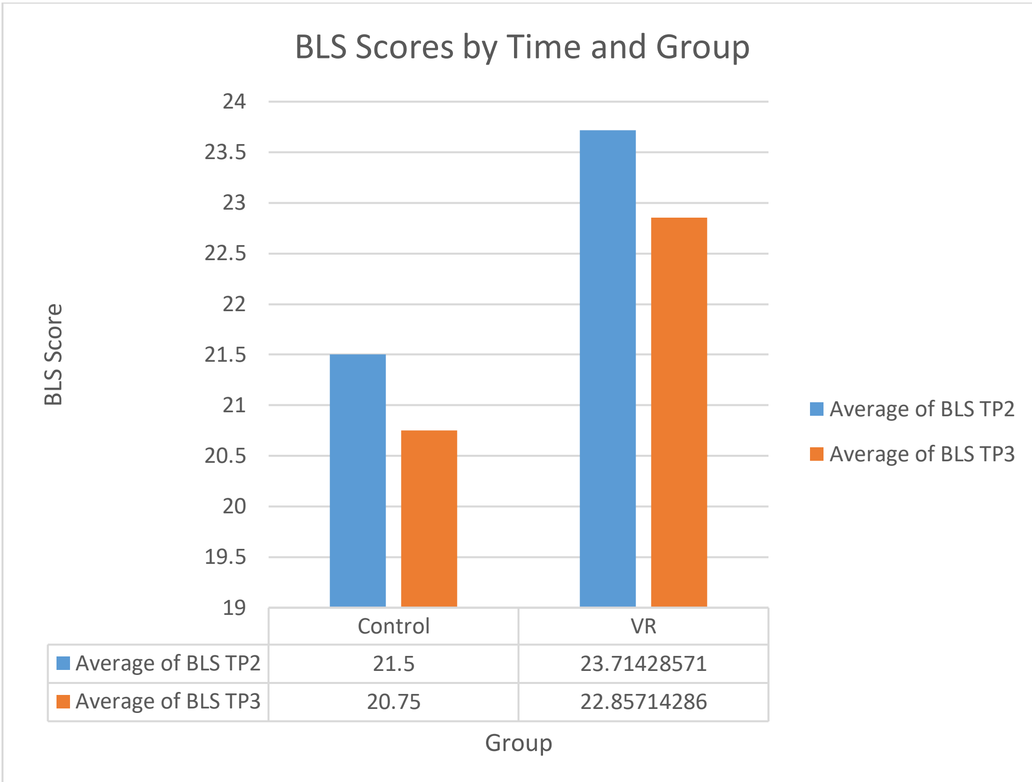
Table 5

BLS Exam Results

Participant ID	**BLS TP2**	**BLS TP3**	**Change**	**Group**
A	23	21	2	Intervention
B	25	24	1	Intervention
C	24	22	2	Intervention
D	22	21	1	Intervention
E	22	24	-2	Intervention
F	25	25	0	Intervention
G	25	23	2	Intervention
H	20	19	1	Control
I	23	22	1	Control
J	20	20	0	Control
K	23	22	1	Control

Figure 8

BLS Scores by Time and Group



Statistical Analysis of BLS Exam Results

A *t*-test is indicated when comparing two means based on either dependent or independent data (Field, 2018). The data set comprises of information about a virtual reality simulation and BLS scores as associated with integration of VR or absence of VR in CPR courses, which can be analyzed with independent *t*-tests performed to compare 3 individual data points: scores between the control and intervention groups at time point 2 (after training) and time point 3 (2 weeks after training) as well as the change in scores between the time frames between groups. The null hypothesis assumes that the intervention has no effect on participant performance.

Assumptions of the Method

Since the *t*-test is a parametric test, it can be prone to biases so must be checked for assumptions of each method, to ensure that the meaning of the numbers is accurate. Field (2018) states that bias comes in two main forms – outliers and violations of assumptions. Outliers are scores that are far removed from the rest of the data, and thus can have an effect on the mean by moving it artificially up or down which makes the mean inaccurate (Field, 2018, p. 171). Outliers also effect estimate of error of the model. Violations of assumptions include additivity and linearity, normality, homoscedasticity, and independence (Field, 2018, p. 173). To test for normality, one may use either the figures of skewness and kurtosis or the Kolmogorov-Smirnov and Shapiro-Wilk tests, both of which compare the sample data to a normally distributed data set which features the same mean and standard deviation (Field, 2018, p. 265). Skewness with positive scores means that there are many low scores and negative scores means that there are many high scores (Field, 2018, p. 267). Positive kurtosis scores indicate a heavy-tailed distribution and negative kurtosis scores indicate a light-tailed distribution (Field, 2018, p. 267). If a non-normal distribution has been identified, one can use non-parametric tests to overcome the problem of non-normal data because they do not assume a normal distribution; these include the Mann-Whitney, Wilcoxion signed-rank, Friedman's, and Kruskal-Wallis tests (Field, 2018, p. 290). Assumptions will be checked in each time point analysis below.

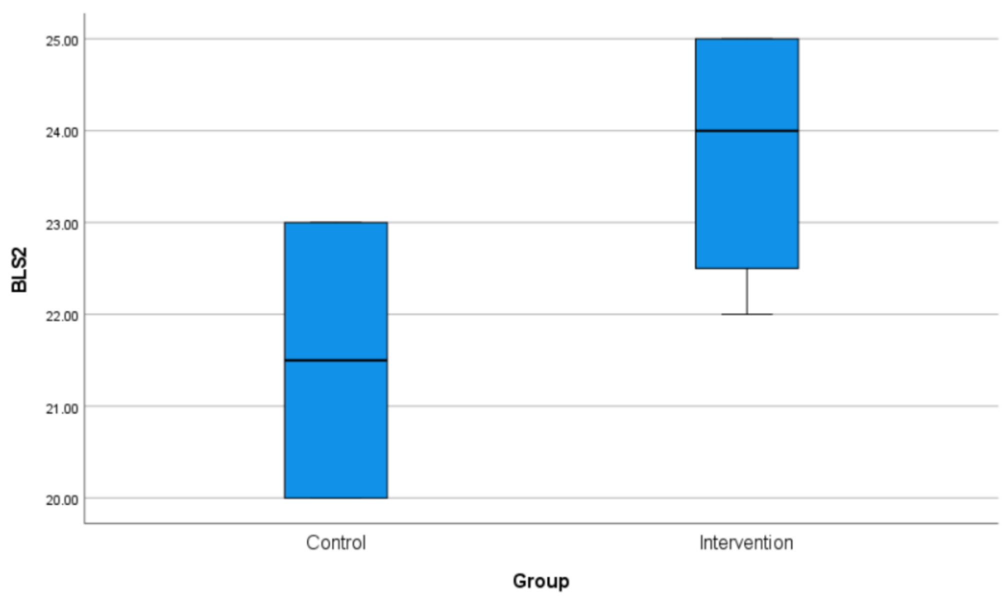
Statistical Analysis for BLS Scores TP2

This analysis pertains to BLS exam scores between groups at time point two, which occurred immediately after training on the day that the participants completed the CPR Course.

Outliers TP2. Outliers are scores that are far removed from the rest of the data, and thus can have an effect on the mean by moving it artificially up or down which makes the mean inaccurate (Field, 2018, p. 171). See figure 9 to observe no outliers, showing that the assumption of no outliers is not violated at time point 2.

Figure 9

Outliers from TP2



Violations of Assumptions TP2

The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. The skewness value for the final score (BLS2) was 0.00 for the control group and -0.359 for the intervention group (meaning there were more high scores than low in both groups) and the kurtosis value was -6.0 for the control group and -2.089 for the intervention group (meaning the distributions are somewhat light-tailed). These results indicated that the data are positively skewed. The Kolmogorov-Smirnov test and Shapiro-Wilk tests all featured significance values greater than 0.05 for the intervention group, so this would indicate a normal distribution, yet the values were less than 0.05 for the control group which signifies non-normal distribution (Field, 2018, p. 270).

Homoscedasticity can be determined by looking at the histograms in Figures 10 and 11 and the Q-Q plots in Figures 12 and 13. The data is not a normal bell curve shape in Figures 10 and 11 (data groups are too small to really tell) but are distributed around the lines in Figures 12 and 13, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene's test in Table 6, which yields a *p*-value of 0.265, meaning that variances are equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is met (Field, 2018, p. 273).

Figure 10

Histogram of Mean Scores for BLS TP2 Control Group

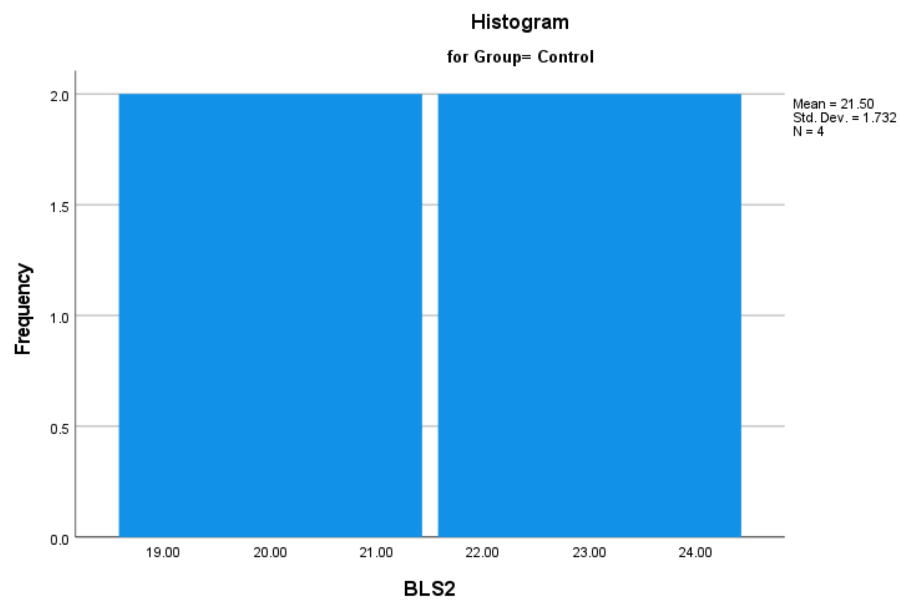


Figure 11

Histogram of Mean Scores for BLS TP2 Intervention Group

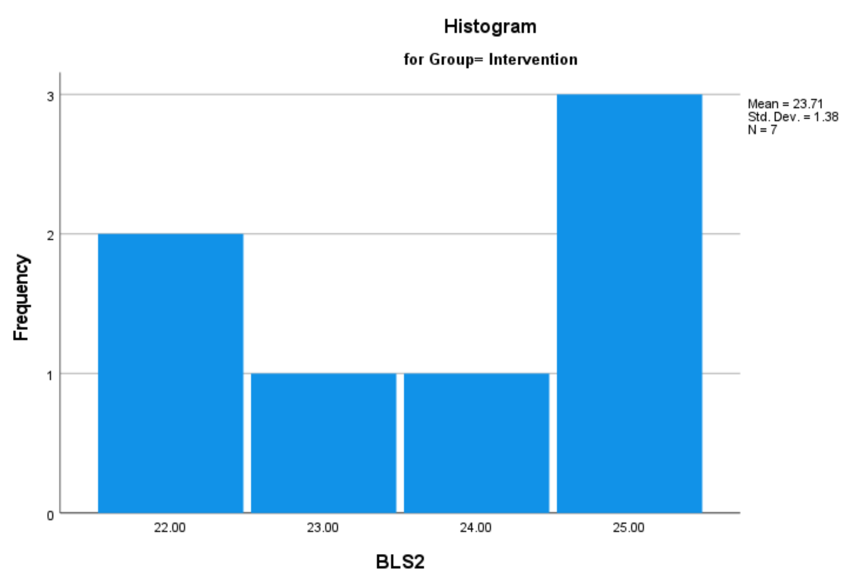


Figure 12

Q-Q Plot of Mean Scores for BLS TP2 Control Group

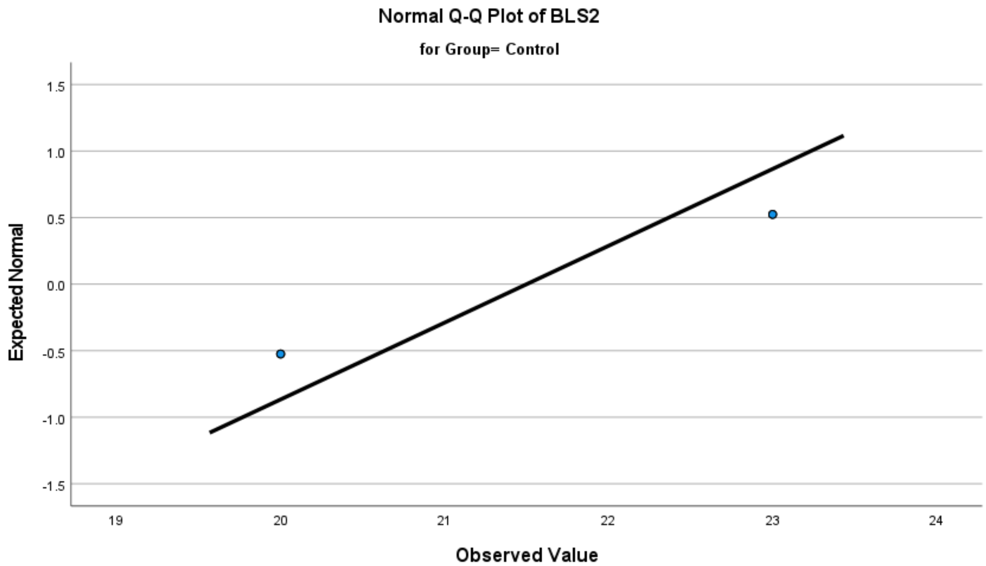
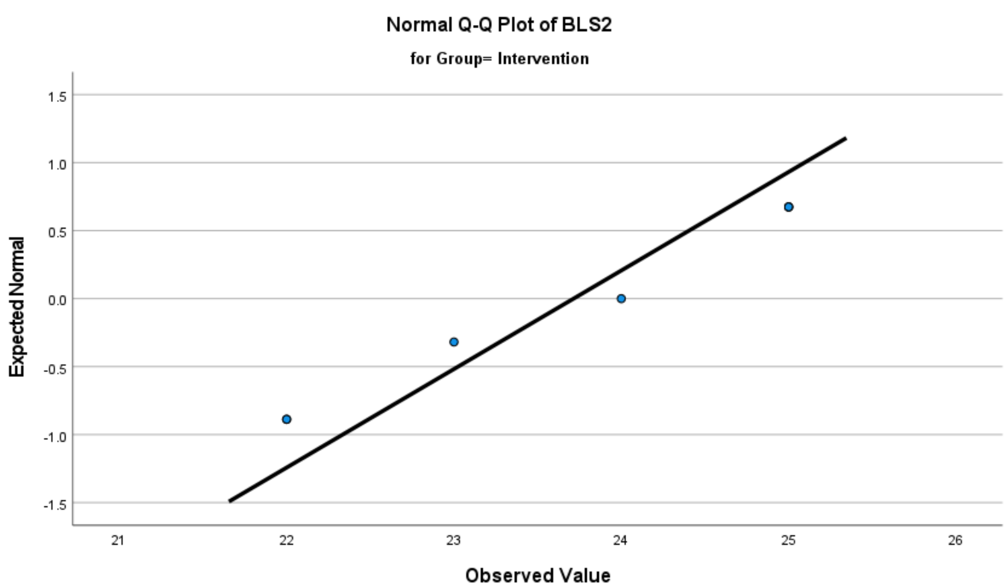


Figure 13

Q-Q Plot of Mean Scores for BLS TP2 Intervention Group



Results and Significance TP2. Results between groups for final scores at time point 2 are presented in tables 6 and 7. The mean of scores in the control group was 21.5 compared to the mean of the intervention group of 23.71. To determine if this is a significant difference, refer to Table 7. Since Levene's test is not significant, we use the figures from the equal variances assumed row. The *t* value is -2.35 with a *p* value of 0.04. This data indicates that, since the p value is less than .05, the means of BLS Scores between groups at time point 2 (immediately after training) show significant difference and that we can reject the null hypothesis, lending evidence to support that VR has a positive effect on the BLS exam (Field, 2018, p. 487).

Table 6

Group Statistics TP2

Group Statistics

					Bootstrap[a]		
						95% Confidence Interval	
			Statistic	Bias	Std. Error	Lower	Upper
BLS 2	Control	Mean	21.50	0.01	0.81	20	23
		Std. Deviation	1.73	-0.36	0.64	0	2.12
		Std. Error Mean	0.87				
	Intervention	Mean	23.71	0.03	0.51	22.75	24.67
		Std. Deviation	1.38	-0.14	0.26	0.55	1.64
		Std. Error Mean	0.52				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 7

Independent Samples Tests Between Groups at TP2

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
BLS TP2	Equal variances assumed	1.41	0.27	-2.35	9	0.04	-2.21	0.944	-4.35	-0.08
	Equal variances not assumed			-2.19	5.23	0.08	-2.21	1.01	-4.78	0.35

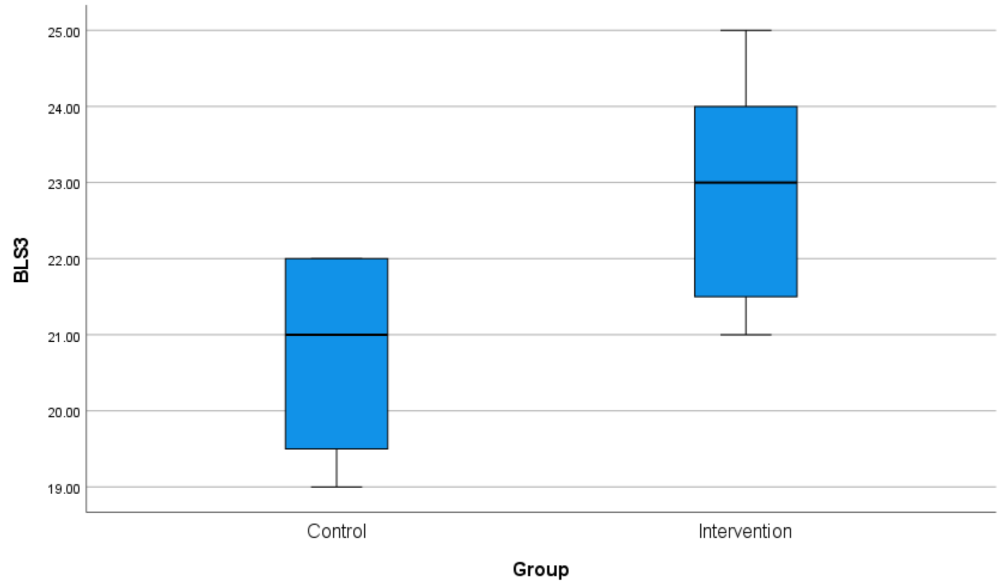
Statistical Analysis for BLS Scores TP3

This analysis pertains to BLS exam scores between groups at time point three, which occurred approximately two weeks after training.

Outliers for TP3. See figure 14 to observe no outliers, showing that the assumption of no outliers is not violated.

Figure 14

Outliers TP3



Violations of Assumptions TP3. The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. The skewness value for the final score (BLS3) was -0.37 for the control group and -0.04 for the intervention group (meaning there were more high scores than low in both groups) and the kurtosis value was -3.90 for the control group and -1.68 for the intervention group (meaning the distributions are somewhat light-tailed). These results indicated that the data are positively skewed. The Kolmogorov-Smirnov test and Shapiro-Wilk tests all featured significance values greater than 0.05 for the intervention group, so this would indicate a normal distribution, yet the values were less than 0.05 for the control group Kolmogorov-Smirnov test which signifies non-normal distribution (Field, 2018, p. 270).

Homoscedasticity can be determined by looking at the histograms in Figures 15 and 16 and the Q-Q plots in Figures 17 and 18. The data is not a normal bell curve shape

in Figures 15 and 16, indicating non-normality. Data are distributed around the lines in Figures 17 and 18, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene’s test in Table 9, which yields a *p*-value of 0.89, meaning that variances are equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is met (Field, 2018, p. 273).

Figure 15

Histogram of Mean Scores for BLS TP3 Control Group

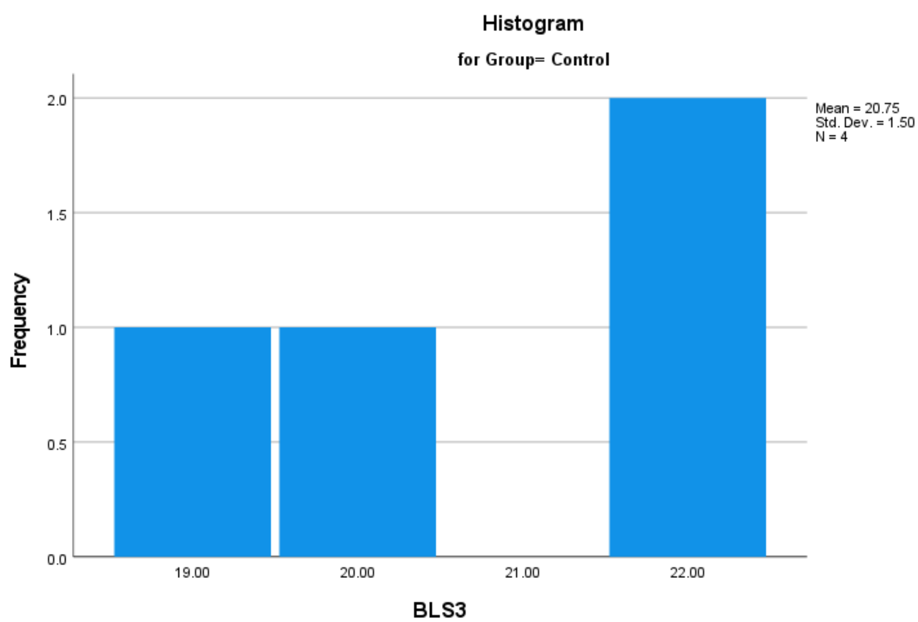


Figure 16

Histogram of Mean Scores for BLS TP3 Intervention Group

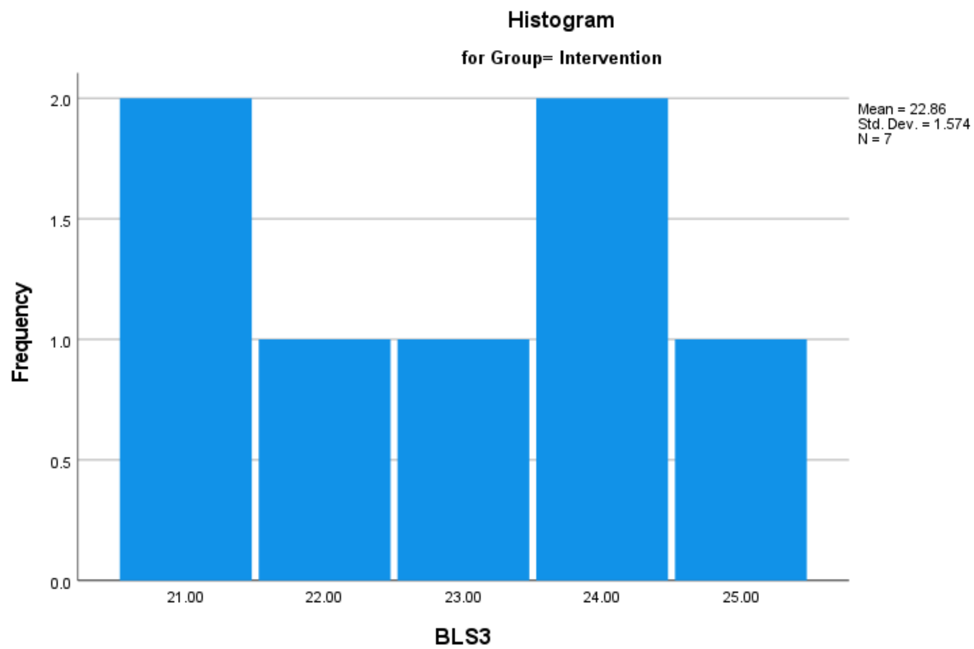


Figure 17

Q-Q Plot of Mean Scores for BLS TP3 Control Group

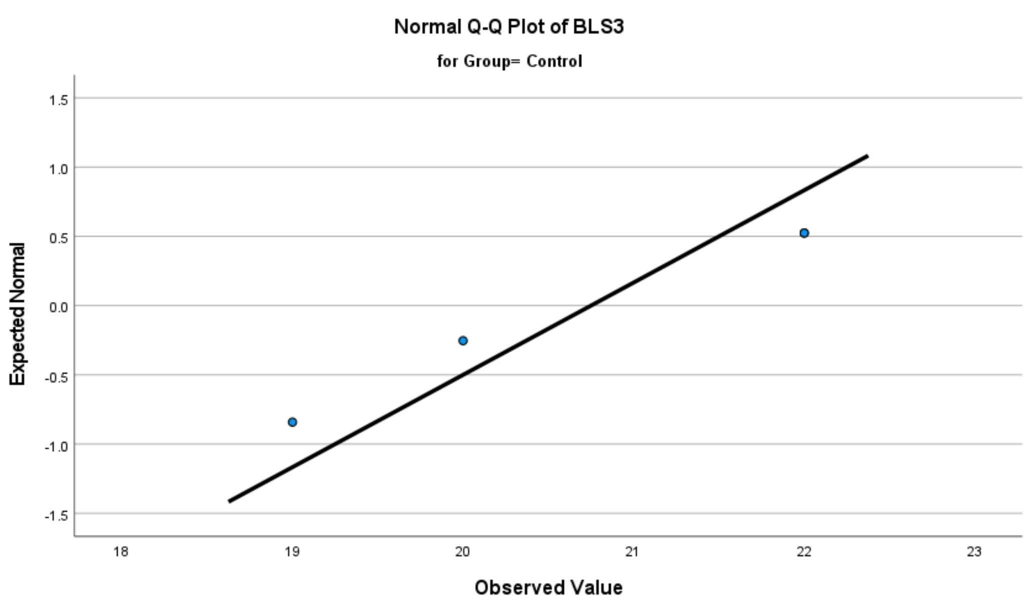
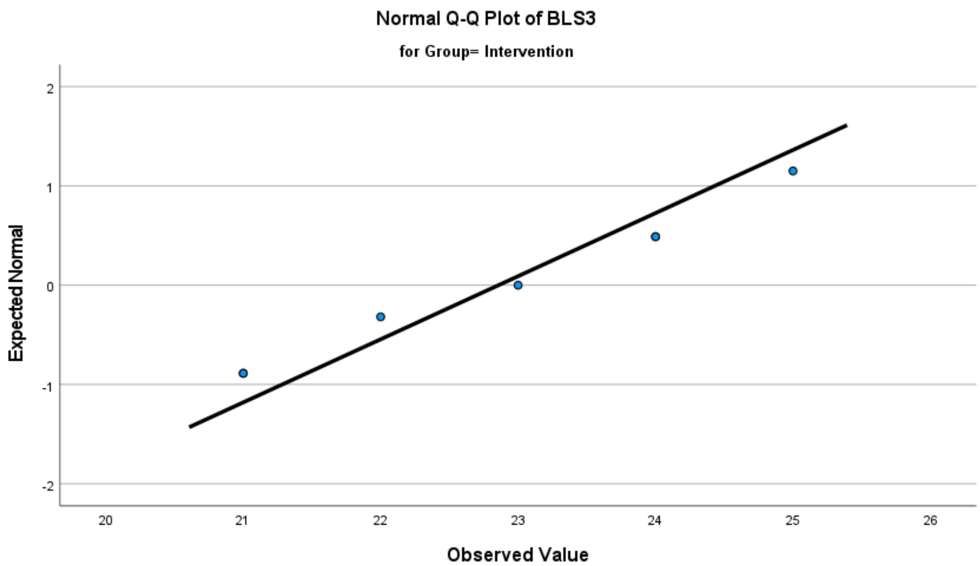


Figure 18

Q-Q Plot of Mean Scores for BLS TP3 Intervention Group



Results and Significance TP3. The mean of scores in the control group was 20.75 compared to the mean of the intervention group of 22.86. To determine if this is a significant difference, refer to Table 9. Since Levene's test is non-significant, we use the figures from the equal variances assumed row. The *t* value is -2.17 with a *p* value of 0.06. This data indicates that, since the p value is greater than 0.05, the means of BLS Scores between groups at time point 3 are not significantly different (Field, 2018, p. 487).

Table 8

Group Statistics TP3

Group Statistics							
					Bootstrap[a]		
					95% Confidence Interval		
			Statistic	Bias	Std. Error	Lower	Upper
BLS 3	Control	Mean	20.75	0.02	0.73	19.33	22.00
		Std. Deviation	1.50	-0.35	0.53	0.00	2.12
		Std. Error Mean	0.75				
	Intervention	Mean	22.86	-0.01	0.58	21.75	24.00
		Std. Deviation	1.57	-0.159	0.30	0.71	1.92
		Std. Error Mean	0.59				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 9

Independent Samples Tests Between Groups at TP3

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2 -tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
BLS TP3	Equal variances assumed	0.02	0.89	-2.17	9	0.06	-2.11	0.97	-4.30	0.09

Continued

Equal variances not assumed	-2.20	6.65	0.07	-2.11	0.96	-4.40	0.18

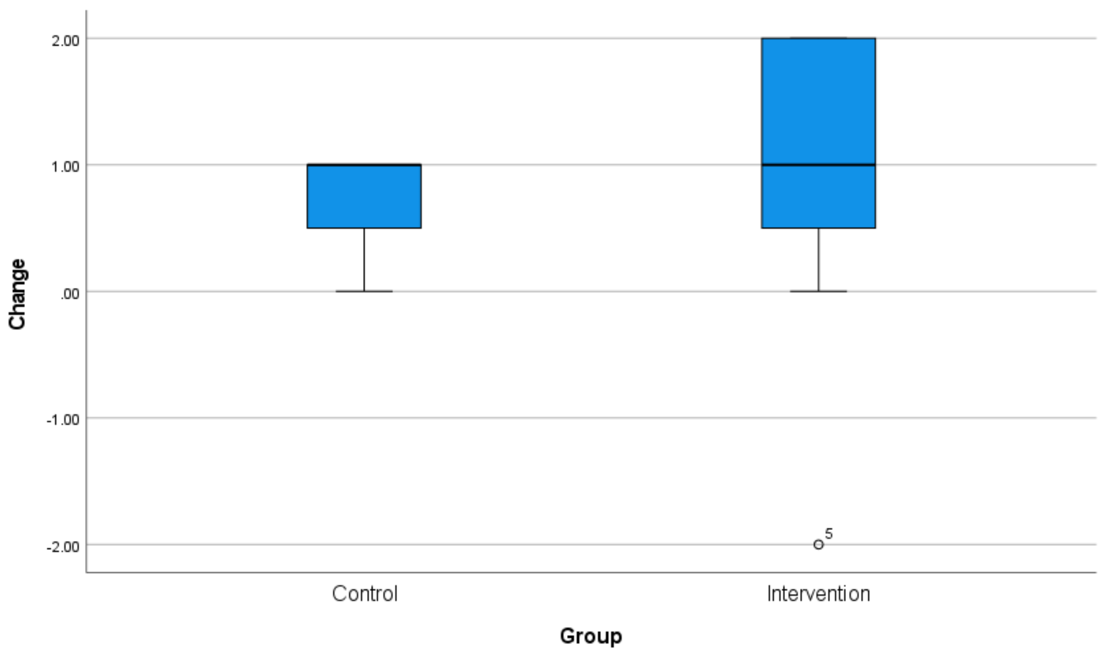
Statistical Analysis for BLS Score Change between TP2 and TP3

This analysis pertains to BLS exam score changes between groups between time points two and three.

Outliers - BLS Change. See figure 14 to observe one outlier, showing that the assumption of no outliers is violated.

Figure 19

Outliers Change



Violations of Assumptions – BLS Change. The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. The skewness value for the change was -2.0 for the control group and -1.45 for the intervention group (meaning there were more high scores than low in both groups) and the kurtosis value was 4.0 for the control group and 1.95 for the intervention group (meaning the distributions are somewhat heavy-tailed). These results indicated that the data are positively skewed. The Kolmogorov-Smirnov test and Shapiro-Wilk tests all featured significance values greater than 0.05 for the intervention group, so this would indicate a normal distribution, yet the values were less than 0.05 for the control group which signifies not normal distribution (Field, 2018, p. 270.

Homoscedasticity can be determined by looking at the histograms in Figures 20 and 21 and the Q-Q plots in Figures 22 and 23. The data is a not a normal bell curve shape in Figures 20 and 21 which indicates heteroscedastic data but distributed around the lines in Figures 22 and 23, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene's test in Table 11, which yields a *p*-value of 0.18, meaning that variances are equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is met (Field, 2018, p. 273).

Figure 20

Histogram of Mean Scores for Change Control Group

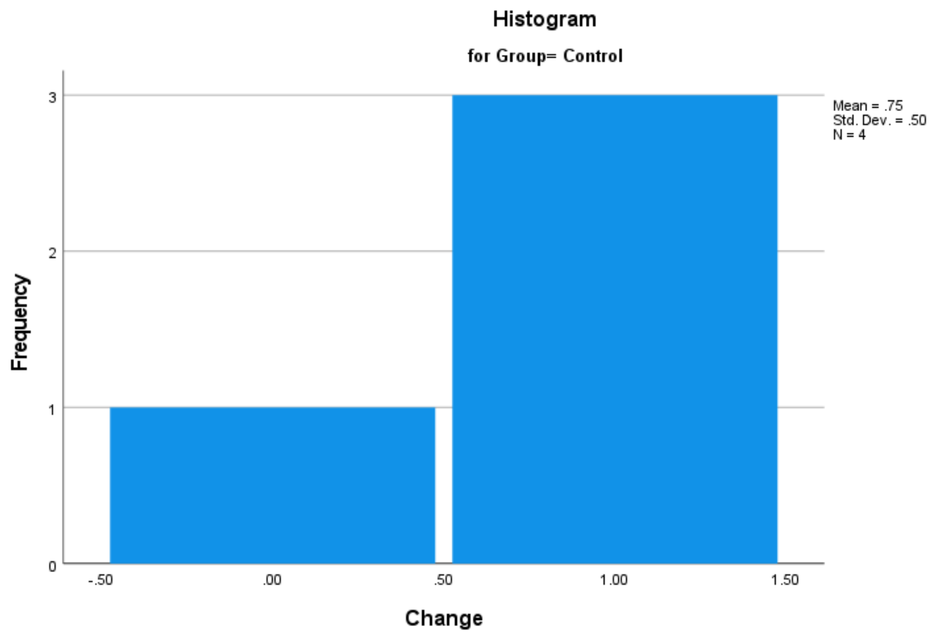


Figure 21

Histogram of Mean Scores for Change Intervention Group

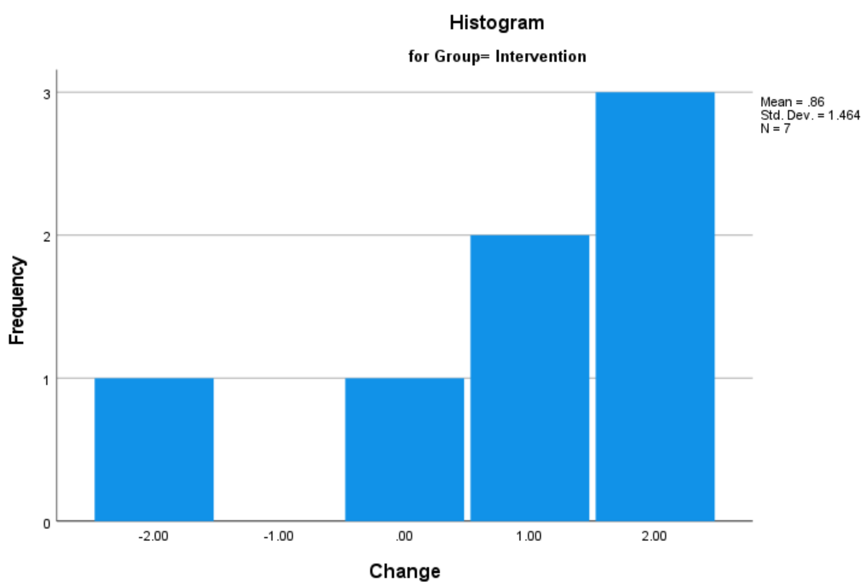


Figure 22

Q-Q Plot of Mean Scores for Change Control Group

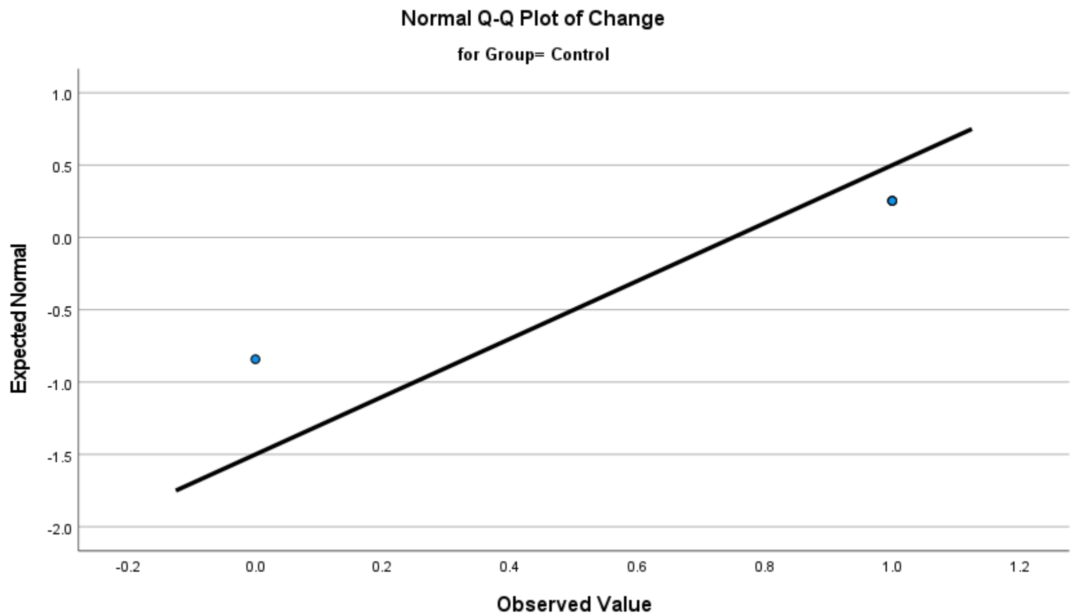
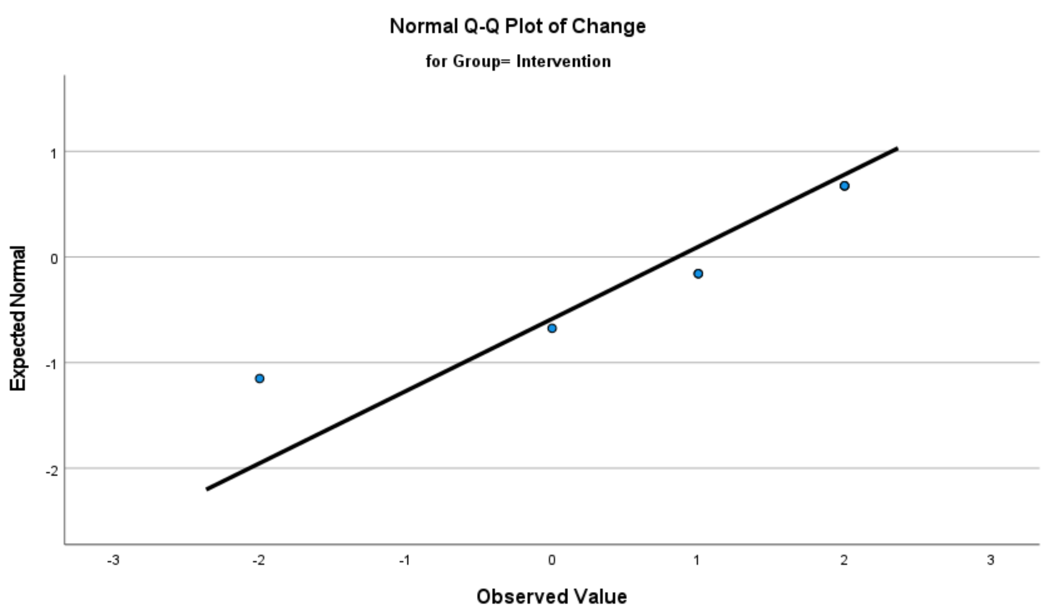


Figure 23

Q-Q Plot of Mean Scores for Change Intervention Group



Results and Significance for Change in BLS Scores between TP2 and TP3. The mean of score changes in the control group was 0.75 compared to the mean of the intervention group of 0.86. To determine if this is a significant difference, refer to Table 11. Since Levene's test is non-significant at 0.18, we use the figures from the equal variances assumed row. The *t* value is -0.14 with a *p* value of 0.89. This data indicates that, since the p value is greater than .05, the means of BLS Scores between group score changes are not significantly different (Field, 2018, p. 487).

Table 10

Group Statistics Change

Group Statistics

				Bootstrap[a]			
						95% Confidence Interval	
			Statistic	Bias	Std. Error	Lower	Upper
Change	Control	Mean	0.75	-0.01	0.24	0.13	1.00
		Std. Deviation	0.50	-0.14	0.25	0.00	0.71
		Std. Error Mean	0.25				
	Intervention	Mean	0.86	-0.02	0.53	-0.29	1.78
		Std. Deviation	1.46	-0.19	0.46	0.45	2.00
		Std. Error Mean	0.55				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 11

Independent Samples Tests Between Groups - Change

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2 - tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
BLS Change	Equal variances assumed	2.09	0.18	-0.14	9	0.89	-0.11	0.77	-1.85	1.64
	Equal variances not assumed			-0.18	8.03	0.86	-0.11	0.61	-1.51	1.29

Self- Efficacy Survey Results

The results from the self-efficacy survey scores aim to answer research question 2 and sub research question 2. Survey items are answered on a 1-5 Likert Scale, with one being disagree and five being agree. This survey was created by adapting the self-efficacy questions posed by Buttussi et al. (2020). The average response per time period per group (control group or VR intervention) is presented. Time point 1 is before training (TP1), time point 2 is immediately after training (TP2), and time point 3 is approximately 2 weeks after initial training (TP3). Self-efficacy survey results are presented in Table 12 and the changes in scores are presented in Table 13.

Table 12

Self-efficacy Survey Results

Survey Item	TP1 Control	TP1 VR	TP2 Control	TP2 VR	TP3 Control	TP3 VR
I feel confident in my ability to perform CPR.	2.75	3.43	4.25	5.00	4.50	5.00
I would be able to check if a person can breathe independently.	3.75	4.29	4.75	5.00	4.75	5.00
I can practice chest compressions correctly.	2.75	3.43	4.75	4.86	4.75	5.00
I would be able to understand when a person has regained vital functions.	3.50	4.00	4.25	4.86	4.00	4.86
I can practice chest compressions without losing time.	3.25	3.00	4.5	4.71	4.75	4.71

Figure 24

Self-Efficacy Result Bar Chart

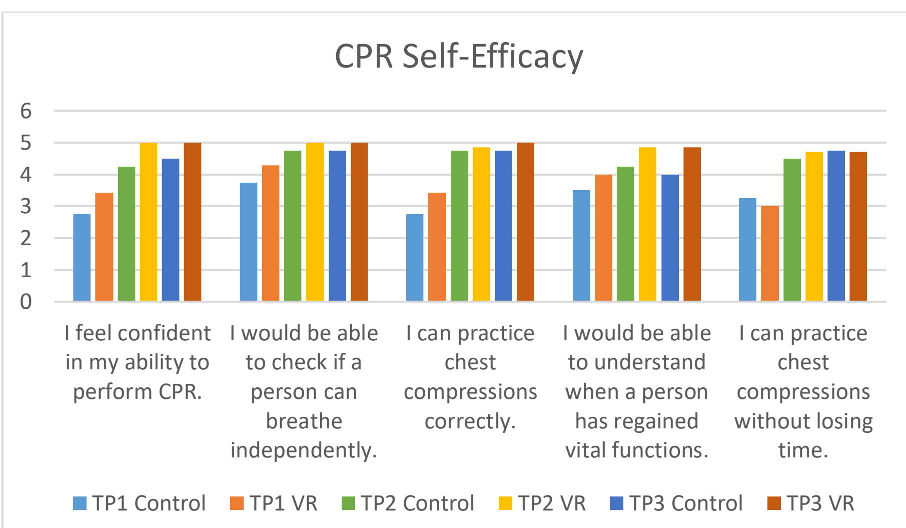


Table 13

Change in Self Efficacy Scores

	TP2-TP1	TP3-TP2	TP3-TP1
Control	1.30	0.05	1.35
Intervention	1.27	0.03	1.29

Questions and Participant Survey Responses

Self-efficacy survey responses are examined in detail in this section.

Question 1. I feel confident in my ability to perform CPR.

Time point one featured a variety of scores – the control group had scores of 1,2,3, and 4. The intervention group had two scores of 5, two scores of 4, one 3, one 2, and one 1. At time point 2, the intervention group all listed scores of 5 and the control group scores had two scores of 5, one 4, and one 3. At time point 3, the intervention group all still had scores of 5 and the control group scored two each with scores of 5 and 4. Participants overall ended up feeling a great sense of self-efficacy after training with this question, which is promising because the training was effective either way. There seems to be a slightly favorable bent towards the intervention group since scores were just a bit higher.

Question 2. I would be able to check if a person can breathe independently.

Time point one featured a variety of scores – the control group had two fives, one 3, and one 2. The intervention group had five scores of 5, one 4, and one 1. At time point 2, the intervention group all listed scores of 5 and the control group scores had three scores of 5, and one 4. At time point 3, the intervention group all still had scores of 5 and the control group scored three scores of 5 and one 4. Participants overall ended up feeling a great sense of self-efficacy after training with this question as well, which is promising because the training was effective either way. There seems to be a slightly favorable bent towards the intervention group since scores were just a bit higher.

Question 3. I can practice chest compressions correctly.

Time point one featured a variety of scores – the control group had one 5, one 3, one 2, and one 1 and the intervention group had two scores of 5, one 4, three 3, and one 1. At time point 2, the intervention group all listed scores of 5 with the exception of one 4 and the control group scores had three scores of 5 and one 4. At time point 3, the intervention group all had scores of 5 and the control group scored three scores of 5 and one 4. Participants overall ended up feeling a great sense of self-efficacy after training with this question as well, which is promising because the training was effective either way.

Question 4. I would be able to understand when a person has regained vital functions.

Time point one featured a variety of scores – the control group had one 5, two 4, and one 1. The intervention group had three scores of 5, two 4, one 3 and one 2. At time point 2, the intervention group all listed scores of 5 with the exception of one 4 and the control group scores had two scores of 5, one 4, and one 3. At time point 3, the intervention group all still had scores of 5 with one 4 and the control group scored two scores of 5, one 4, and one 2. Participants in the intervention group overall ended up feeling a great sense of self-efficacy after training with this question as well, but the control group scores were slightly lower. There seems to be a slightly favorable bent towards the intervention group since scores were just a bit higher.

Question 5. I can practice chest compressions without losing time.

Time point one featured a variety of scores – the control group had two 5, one 2, and one 1. The intervention group had one 5, one 4, three 3, one 2 and one 1. At time point 2, the intervention group all listed five scores of 5 and two 4 and the control group scores had two scores of 5 and two 4. At time point 3, the intervention group all still listed five scores of 5 and two 4 and the control group scores had three scores of 5 and one 4. Participants overall ended up feeling a great sense of self-efficacy after training with this question as well, which is promising because the training was effective either way.

Statistical Analysis of Self-Efficacy Survey Results

The self-efficacy survey measured on a scale of 1-5 (least to most confident) how confident participants felt about their skills. Change of scores was calculated by subtracting the earlier time results from later time results. Thus, a lower value would indicate that loss of learning occurred less and a greater value would mean that self-efficacy scores had lessened over time.

Assumptions of the Method

Since the *t*-test is a parametric test, it can be prone to biases so must be checked for assumptions of each method, to ensure that the meaning of the numbers is accurate. Field (2018) states that bias comes in two main forms – outliers and violations of assumptions. These assumptions will be checked for each change in time frame examined. Outliers are scores that are far removed from the rest of the data, and thus can have an effect on the mean by moving it artificially up or down which makes the mean inaccurate (Field, 2018, p. 171). Outliers also effect estimate of error of the model.

Violations of assumptions include additivity and linearity, normality, homoscedasticity, and independence (Field, 2018, p. 173). The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. To test for normality, one may use either the figures of skewness and kurtosis or the Kolmogorov-Smirnov and Shapiro-Wilk tests, both of which compare the sample data to a normally distributed data set which features the same mean and standard deviation (Field, 2018, p. 265). Skewness with positive scores means that there are many low scores and negative scores means that there are many high scores (Field, 2018, p. 267). Positive kurtosis scores indicate a heavy-tailed distribution and negative kurtosis scores indicate a light-tailed distribution (Field, 2018, p. 267). If a non-normal distribution has been identified, one can use non-parametric tests to overcome the problem of non-normal data because they do not assume a normal distribution; these include the Mann-Whitney, Wilcoxion signed-rank, Friedman's, and Kruskal-Wallis tests (Field, 2018, p. 290). Assumptions of the method will be checked for each instance of statistical analysis below.

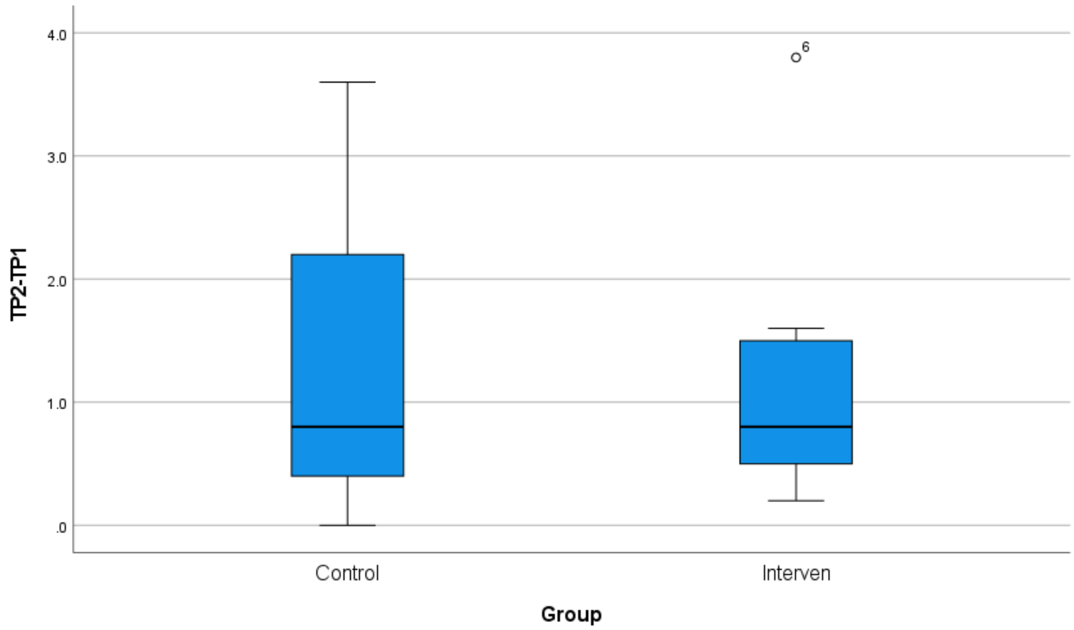
Statistical Analysis for Change from Time Point 1 to Time Point 2

This section explores the results of the differences in total self-efficacy average scores between pre-training (TP1) and immediately after training (TP2).

Outliers TP1-TP2. See figure 25 to observe one outlier between TP1 and TP2 for change in self-efficacy, showing that the assumption of no outliers is violated.

Figure 25

Outliers from TP1-TP2



Violations of Assumptions TP1-TP2. The skewness value for the change in self efficacy scores between TP1 and TP2 was 1.65 for the control group and -1.79 for the intervention group (meaning there were more low scores than high in both groups) and the kurtosis value was 3.10 for the control group and 3.50 for the intervention group (meaning the distributions are somewhat heavy-tailed). The Kolmogorov-Smirnov test and Shapiro-Wilk tests all featured significance values greater than 0.05 for the intervention group, so this would indicate a normal distribution, yet one value was less than 0.05 for the control group which signifies not normal distribution (Field, 2018, p. 270).

Homoscedasticity can be determined by looking at the histograms in Figures 26 and 27 and the Q-Q plots in Figures 28 and 29. The data is not a normal bell curve shape in Figures 26 and 27 which indicates non-normality. Data are distributed around the lines in Figures 28 and 29, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene's test in Table 14, which yields a *p*-value of 0.59, meaning that variances are equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is met (Field, 2018, p. 273).

Figure 26

Histogram of Mean Scores for Self-efficacy Change TP1-TP2 Control Group

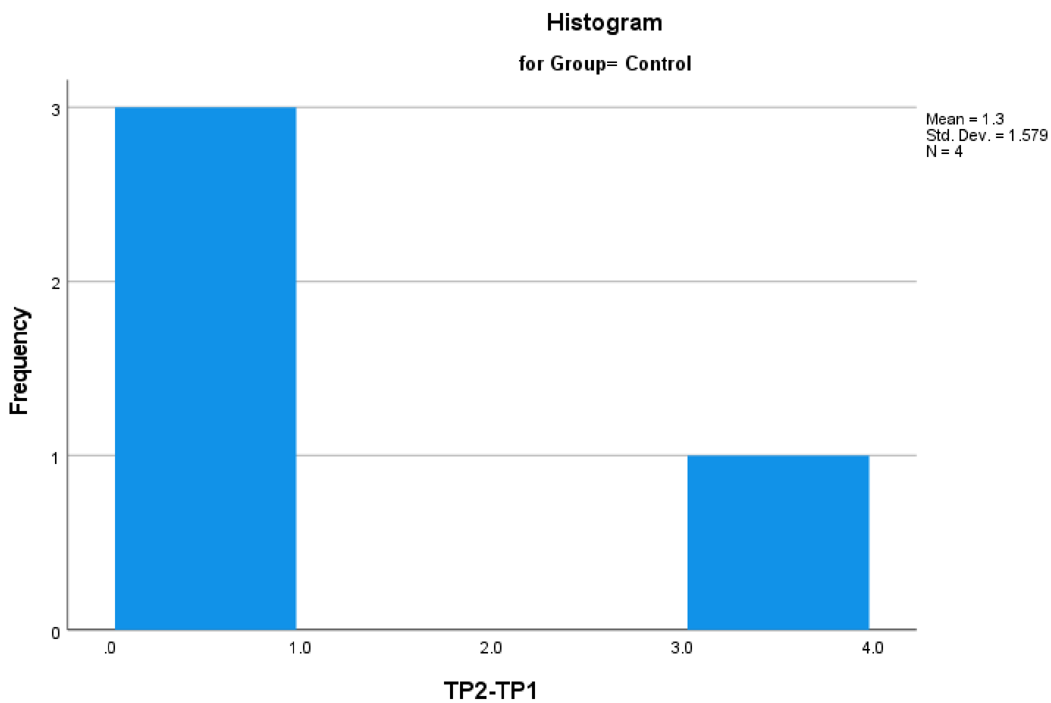


Figure 27

Histogram of Mean Scores for Self-efficacy Change TP1-TP2 Intervention Group

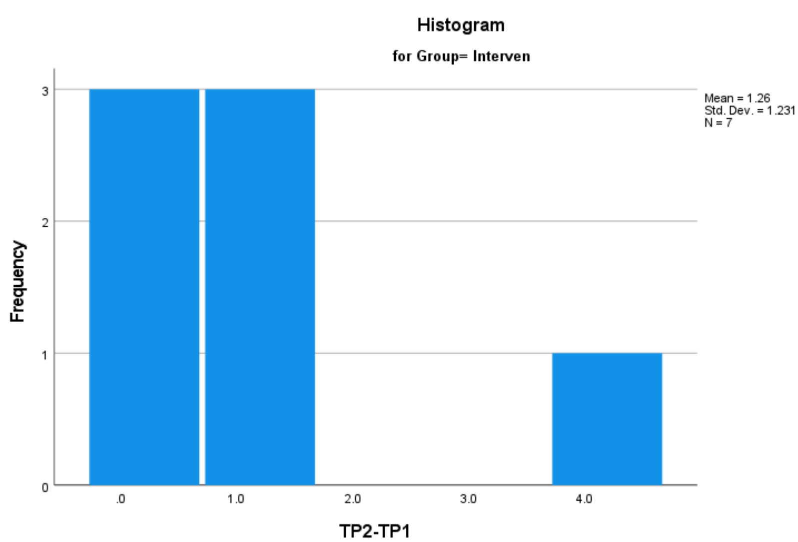


Figure 28

Q-Q Plot of Mean Scores for Self-efficacy Change TP1-TP2 Control Group

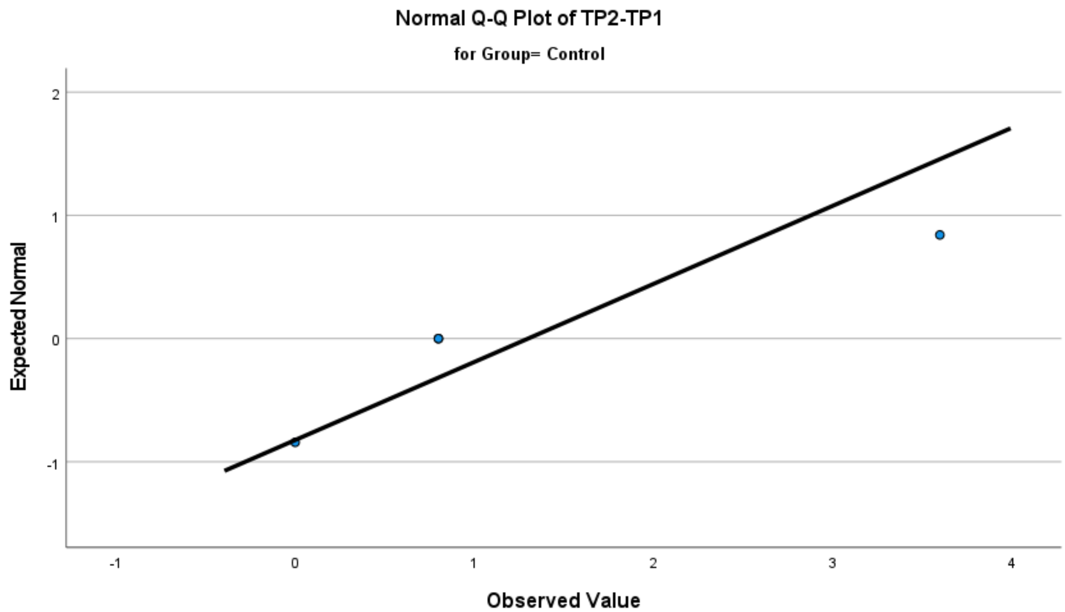
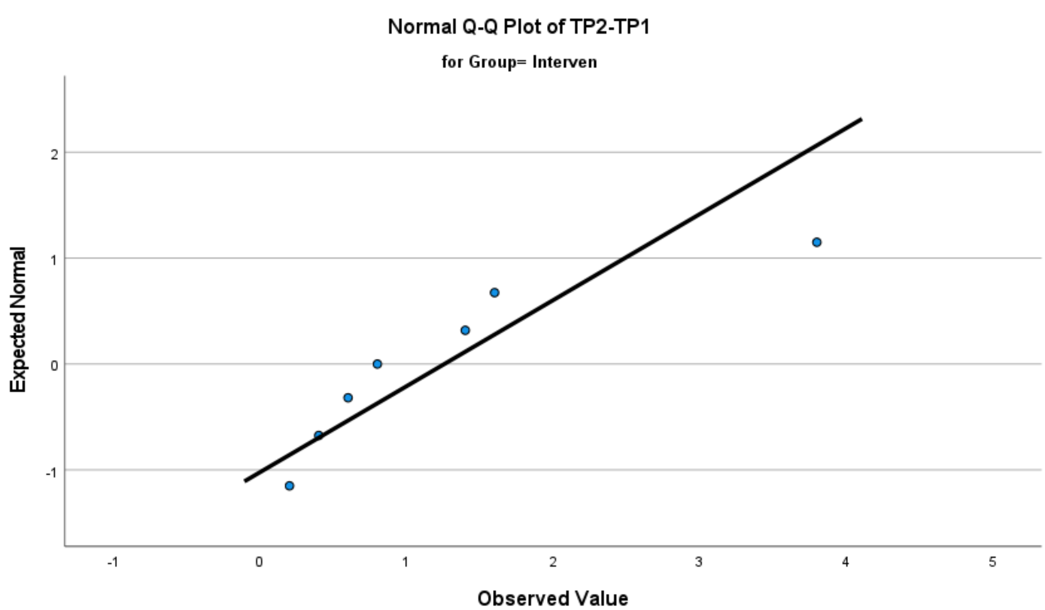


Figure 29

Q-Q Plot of Mean Scores for Self-efficacy Change TP1-TP2 Intervention Group



Self-Efficacy Results and Significance for TP1-TP2. The mean of scores in the control group was 1.30 compared to the mean of the intervention group of 1.26, presented in Table 14. To determine if this is a significant difference, refer to Table 15. Since Levene's test is non-significant, we use the figures from the equal variances assumed row. The *t* value is -0.05 with a *p* value of 0.96. This data indicates that, since the p value is greater than .05, the means of Self-efficacy score changes between TP1 and TP2 between groups are not significantly different (Field, 2018, p. 487).

Table 14

Self-efficacy Change Group Statistics TP1-TP2

Group Statistics

					Bootstrap[a]		
						95% Confidence Interval	
			Statistic	Bias	Std. Error	Lower	Upper
TP1-TP2	Control	Mean	1.30	0.02	0.80	0.14	3.60
		Std. Deviation	1.58	-0.41	0.69	0.00	2.08
		Std. Error Mean	0.79				
	Intervention	Mean	1.26	0.01	0.44	0.56	2.23
		Std. Deviation	1.23	-0.17	0.44	0.27	1.71
		Std. Error Mean	0.47				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 15

Independent Samples Tests Between Groups for Self-efficacy Change TP1-TP2

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2 -tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
TP1-TP2	Equal variances assumed	0.31	0.59	-0.05	9	0.96	-0.04	0.85	-1.97	1.88
	Equal variances not assumed			-0.05	5.14	0.96	-0.04	0.92	-2.38	2.29

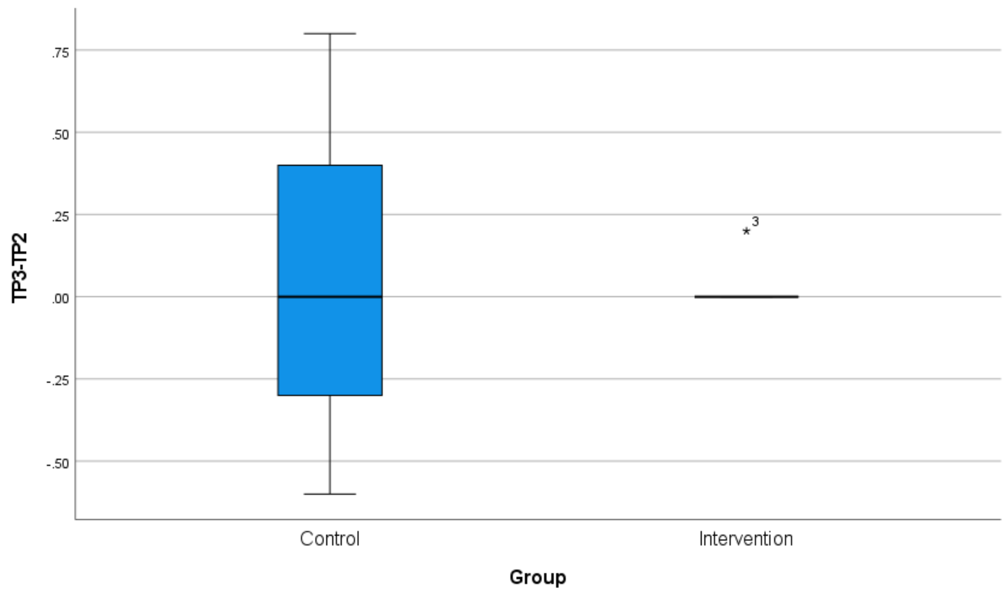
Statistical Analysis for Change from Time Point 2 to Time Point 3

This section explores the results of the differences in total self-efficacy average scores between the survey given immediately after training (TP2) and approximately two weeks after training (TP3).

Outliers TP2-TP3. See figure 30 to observe one outlier between TP2 and TP3 for change in self-efficacy, showing that the assumption of no outliers is violated.

Figure 30

Outliers from TP2-TP3



Violations of Assumptions TP2-TP3. The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. The skewness value for the change in self efficacy scores between TP2 and TP3 was 0.52 for the control group and 2.65 for the intervention group (meaning there were more low scores than high in both groups) and the kurtosis value was 1.65 for the control group and 7.00 for the intervention group (meaning the distributions are heavy-tailed). The Kolmogorov-Smirnov test and Shapiro-Wilk tests 3 out of 4 times featured significance values less than 0.05 for the both groups, which signifies not normal distribution (Field, 2018, p. 270).

Homoscedasticity can be determined by looking at the histograms in Figures 31 and 32 and the Q-Q plots in Figures 33 and 34. The data is not a normal bell curve shape

in Figure 32 which indicates non-normality. Data are distributed around the lines in Figures 33 and 34, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene's test in Table 17, which yields a *p*-value of 0.04, meaning that variances are not equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is not met (Field, 2018, p. 273).

Figure 31

Histogram of Mean Scores for Self-efficacy Change TP2-TP3 Control Group

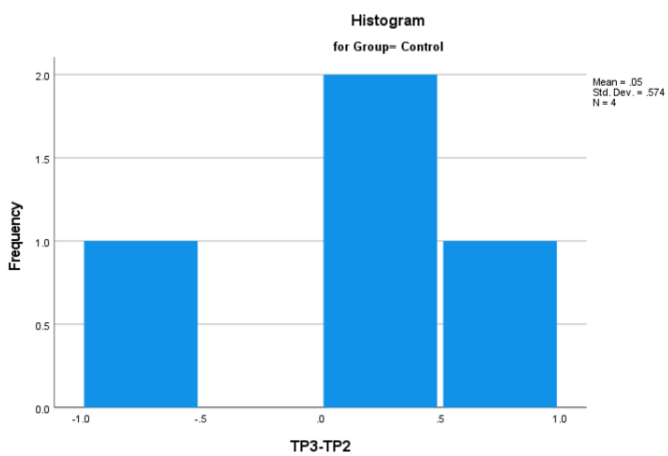


Figure 32

Histogram of Mean Scores for Self-efficacy Change TP2-TP3 Intervention Group

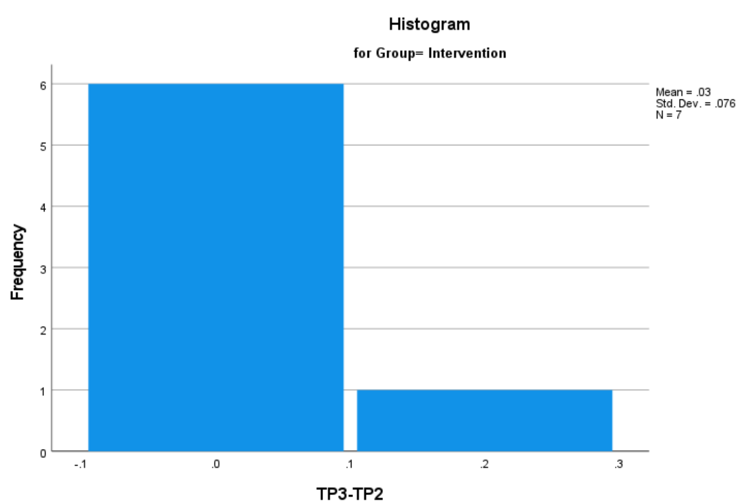


Figure 33

Q-Q Plot of Mean Scores for Self-efficacy Change TP2-TP3 Control Group

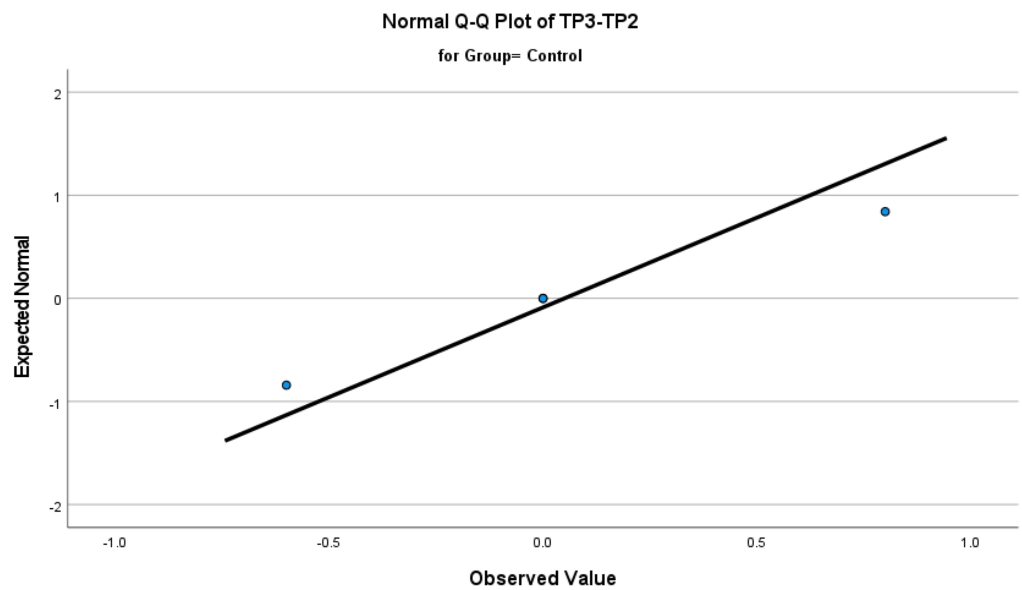
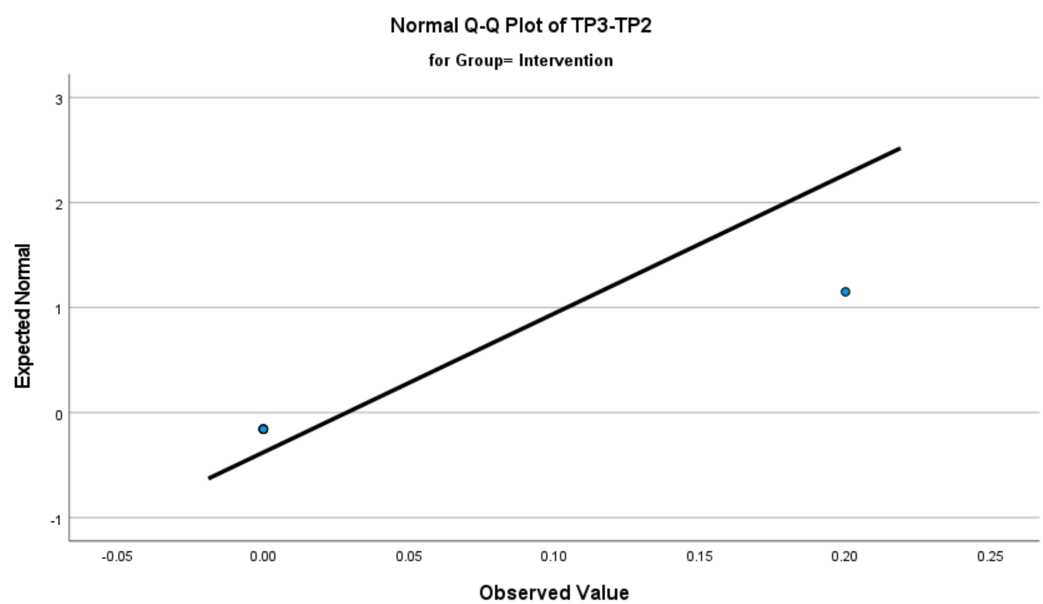


Figure 34

Q-Q Plot of Mean Scores for Self-efficacy Change TP2-TP3 Intervention Group



Self-Efficacy Results and Significance for TP2-TP3. The mean of scores in the control group was 0.05 compared to the mean of the intervention group of 0.03, as presented in Table 16. To determine if this is a significant difference, refer to Table 17. Since Levene's test is significant with a *p* value of 0.04, we use the figures from the equal variances not assumed row. The *t* value is -0.07 with a *p* value of 0.95. This data indicates that, since the p value is greater than .05, the means of Self-efficacy score changes between TP2 and TP3 between groups are not significantly different (Field, 2018, p. 487).

Table 16

Self-efficacy Change Group Statistics TP2-TP3

Group Statistics

					Bootstrap		
						95% Confidence Interval	
			Statistic	Bias	Std. Error	Lower	Upper
TP2-TP3	Control	Mean	0.05	-0.002	0.28	-0.60	0.64
		Std. Deviation	0.57	-0.12	0.22	0.00	0.81
		Std. Error Mean	0.29				
	Intervention	Mean	0.03	0.00	0.03	0.00	0.09
		Std. Deviation	0.08	-0.02	0.04	0.00	0.11
		Std. Error Mean	0.03				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 17

Independent Samples Tests Between Groups for Self-efficacy Change TP2-TP3

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2 -tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
TP2 - TP3	Equal variances assumed	5.47	0.04	-0.10	9	0.92	-0.02	0.21	-0.50	0.46
	Equal variances not assumed			-0.07	3.06	0.95	-0.02	0.29	-0.93	0.89

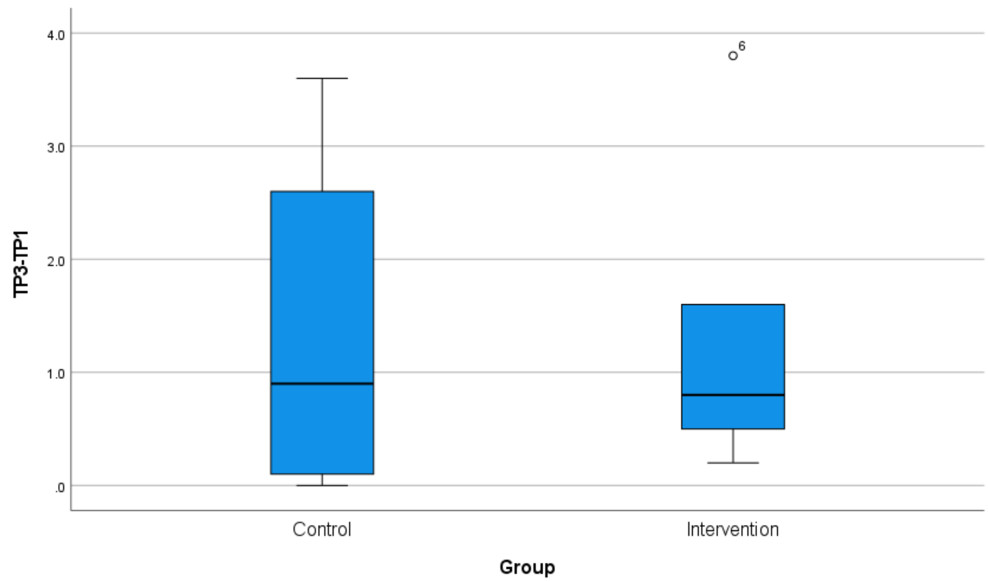
Statistical Analysis for Change from Time Point 1 to Time Point 3

This section explores the results of the differences in total self-efficacy average scores between the survey given before training (TP1) and approximately two weeks after training (TP3).

Outliers TP1-TP3. See figure 35 to observe one outlier between TP1 and TP3 for change in self-efficacy, showing that the assumption of no outliers is violated.

Figure 35

Outliers from TP1-TP3



Violations of Assumptions TP1-TP3. The independent observations assumption is met because each population is independent of the other. Interval or ratio types of the dependent variable assumption is also met since the dependent variable is a scale. The skewness value for the change in self efficacy scores between TP1 and TP3 was 1.08 for the control group and 1.67 for the intervention group (meaning there were more low scores than high in both groups) and the kurtosis value was -0.03 for the control group and 3.01 for the intervention group (meaning the distributions are heavy-tailed). The Kolmogorov-Smirnov test and Shapiro-Wilk tests 3 out of 4 times featured significance values greater than 0.05 for the both groups, which signifies normal distribution (Field, 2018, p. 270.

Homoscedasticity can be determined by looking at the histograms in Figures 36 and 37 and the Q-Q plots in Figures 38 and 39. The data is not a normal bell curve shape

in Figure 36 or 37 which indicates non-normality. Data are distributed around the lines in Figures 38 and 39, so thus are homoscedastic which means that confidence levels and significance tests are valid (Field, 2018, p. 287). Homogeneity of variance may also be examined using Levene's test in Table 19, which yields a *p*-value of 0.49, meaning that variances are equal using the standard of .05 being the accepted parameter thus the homogeneity of variance assumption is met (Field, 2018, p. 273).

Figure 36

Histogram of Mean Scores for Self-efficacy Change TP1-TP3 Control Group

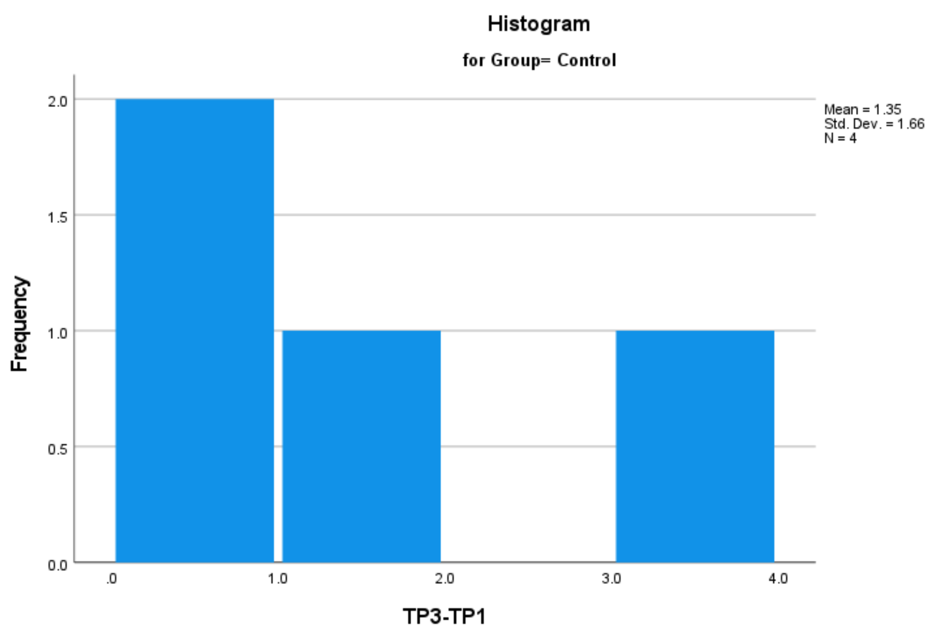


Figure 37

Histogram of Mean Scores for Self-efficacy Change TP1-TP3 Intervention Group

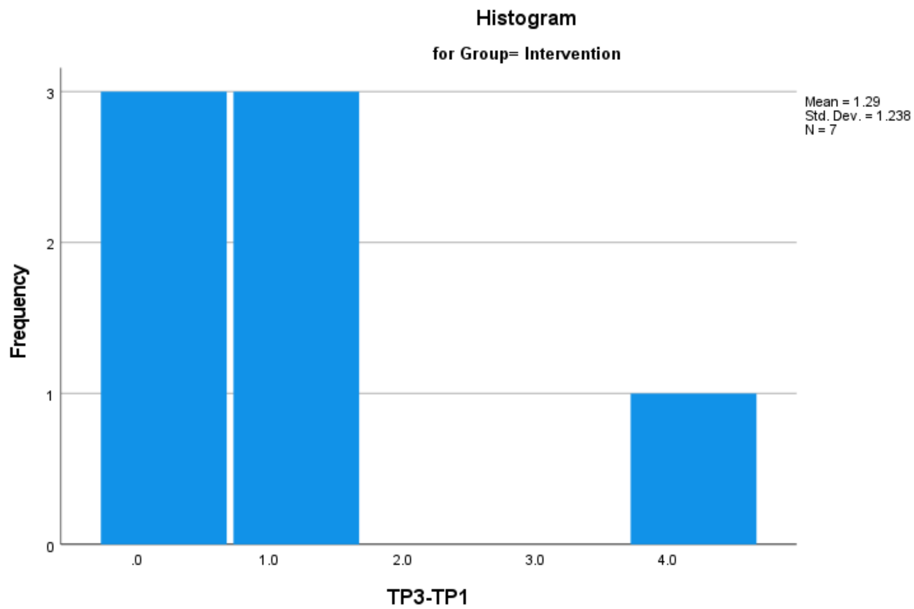


Figure 38

Q-Q Plot of Mean Scores for Self-efficacy Change TP1-TP3 Control Group

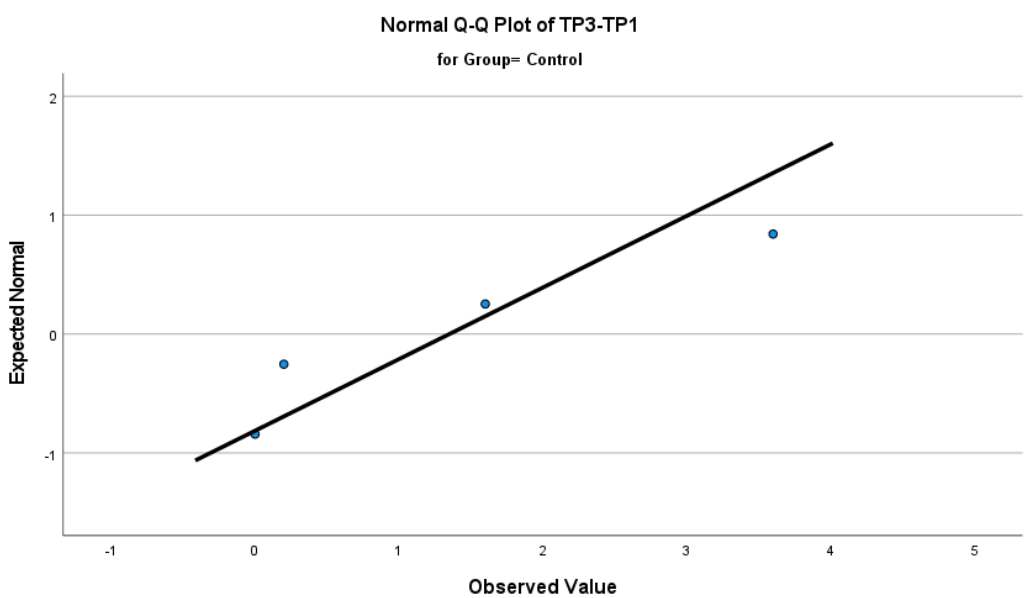
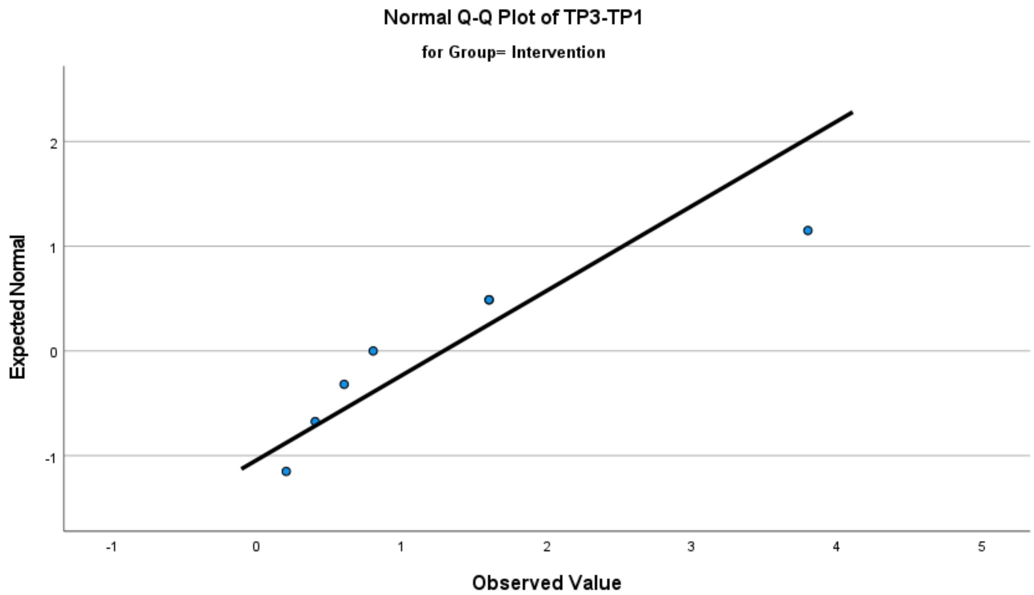


Figure 39

Q-Q Plot of Mean Scores for Self-efficacy Change TP1-TP3 Intervention Group



Self-Efficacy Results and Significance for TP1-TP3. The mean of scores in the control group was 1.35 compared to the mean of the intervention group of 1.29, presented in Table 18. To determine if this is a significant difference, refer to Table 19. Since Levene's test is not significant at p = 0.49, we use the figures from the equal variances assumed row. The t value is -0.07 with a p value of 0.94. This data indicates that, since the p value is greater than .05, the means of Self-efficacy score changes between TP1 and TP3 between groups are not significantly different (Field, 2018, p. 487).

Table 18

Self-efficacy Change Group Statistics TP1-TP3

Group Statistics							
					Bootstrap[a]		
					95% Confidence Interval		
			Statistic	Bias	Std. Error	Lower	Upper
TP1-TP3	Control	Mean	1.35	0.04	0.81	0.00	3.10
		Std. Deviation	1.66	-0.35	0.60	0.00	2.40
		Std. Error Mean	0.83				
	Intervention	Mean	1.29	0.01	0.46	0.57	2.34
		Std. Deviation	1.24	-0.17	0.43	0.30	1.72
		Std. Error Mean	0.47				

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 19

Independent Samples Tests Between Groups for Self-efficacy Change TP1-TP3

		Levene's Test for Equality of Variances					T-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2 -tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
TP1-TP3	Equal variances assumed	0.51	0.49	-0.07	9	0.94	-0.06	0.87	-2.04	1.91
	Equal variances not assumed			-0.07	4.96	0.95	-0.06	0.95	-2.52	2.39

Virtual Reality Post Survey

The VR post survey was created to gather data about the VR experience. The participants in the intervention group did not have a great deal of experience using VR, but overall enjoyed a positive experience, as evidenced by the comments listed in Table 20.

Short Answer Items

1. Do you have any previous VR experience?

   Of the seven VR participants, three had previous VR experience and four did not.

2. Do you own a VR headset?

   Of the seven VR participants, none owned a VR headset.

3. Please comment on the VR experience in as much detail as possible (pros and cons).

   Comments about the VR experience are presented in Table 20.

Table 20

Comments from Participants about the VR Experience

Participant ID	Comment
A	“I enjoyed using this device. My only con is maneuvering through joy stick.”
B	“Outstanding! I've taken CPR Courses every year for 27 years. It is always difficult to "remember" changes to the protocol year to year. VR has allowed me to reinforce the in-class learning in a new and very memorable way. It has also made a very "dry" class exciting, engaging, and interactive. BRAVO! Dr. Bass was an amazing instructor. Best, most knowledgeable, most efficient instructor I've had in 27 years! GREAT JOB!”
C	“I tried one with my phone, took a class ILX Fundamentals, had a VR demo in class.”
D	“Once I got into the app (that was my biggest issue), it was relatively simple to use. However, I did have an issue getting the AED pads onto the person's chest. More directions inside the app would have helped me use it better.”
E	“Very cool technology! Consider employing a familiarization practice to remove error effects-in other words the participant is less focused how to work the technology and can focus on the task.”
F	“Pro - the statistics in the VR game allow you to easily see improvements in keeping a steady rate of compressions. It was also helpful in establishing the rhythm/spacing of the compressions and in establishing the overall rhythm of compressions/breaths/compressions/breaths/compressions. The sound effects in the VR game was a good way to practice the ability to tune out distractions while going through the steps of CPR and delivering compressions. Found that when using the VR again, was able to see this improvement in being able to focus on the compressions and procedures, but still be aware of surroundings. Overall, liked being able to repeat/practice with the VR as much as desired.

Continued

Participant ID	Comment
	Con – while the VR simulation was good at covering the basic steps / process and repetitions needed for CPR, did not allow you practice some of the details in CPR, like tilting the head to make sure the airway is open. With the VR simulation as it is, worked well in conjunction with the physical practice afforded by in person training; if one was looking to have entirely VR simulation training, would need a more detailed simulation. Both facilitators were excellent!! Dr. Bass incorporated real life/practical examples."
G	"Very realistic. Had to adjust to the screen and visual perception given wearing bi-focals. Fun. Having never used VR, took a few minutes to figure out the controller."

Likert Scale Items

Items were to be answered on a 1-5 Likert Scale: 1 is disagree and five is agree. Table 21 presents the average of responses. Again, the VR experience proved positive for the participants, with the items about the VR experience all being rated at 4.71 on average and higher. These results are promising for implementation of VR to assist learning outcomes.

Table 21

Average Likert Scale Averages for VR Survey

Survey Item	Average
After this experience, I would consider using VR for other learning experiences.	5.00
The VR experience was pleasurable for me.	4.86
I was satisfied with the outcome of training using VR practice for CPR recertification.	4.86
The VR experience enhanced my performance on the BLS Certification exam.	4.71

(continued)

I would have preferred more time with the VR headset.	3.86
I would have preferred more time with the mannequin.	2.57
I would recommend VR training to others.	5.00

Emerging Themes about Virtual Reality

Themes are overall outcomes of coding ideas to create synthesis (Saldaña, 2009). Qualitative data was examined and coded into ideas which create patterns and categories – which leads to the discovery of themes within the data. Overall, participants were excited to try the "Saving Lives" VR simulation and interact with the VR headsets. Nobody in the VR group experienced ill effects such as nausea and dizziness. There were a few who needed help finding the simulation in the menu, but overall, they were able to enter the simulation quickly. Respondents indicated feeling enjoyment and pleasure while completing the simulation and indicated satisfaction in the survey items. Of the seven VR participants, five expressed outright satisfaction in their comments (Table 20) in using VR. Five participants also expressed that it took a little while to navigate through using the technology. This is important to consider when offering learning through VR because practitioners will need to provide ample time for the users to get accustomed to using the technology.

Summary of Results

Chapter V included a detailed analysis of results from this study. The results from time point 2 showed a significant difference between the control group and the intervention group BLS scores, rejecting the null hypothesis and lending support to implement VR in CPR training. For time point 3 and the change between time points, the result differences between groups of BLS exam scores were not supported as significant in statistical analysis. The null hypothesis thus must be accepted. For the self-efficacy score differences between groups for all time point differences, there was also not supported significance and the null hypothesis was accepted. The post survey from the intervention group revealed some positive comments as well as some challenges to using the VR headsets to supplement CPR learning. Chapter VI will feature discussion for each research question and its connection to the known literature as well as recommendations for future research.

CHAPTER VI

Discussion

Introduction

This study aimed to examine the relationships between learning procedural skills and factual knowledge in a CPR re-certification course with a supplemental virtual reality simulation “Saving Lives” as compared to a control group with no VR simulation. This was measured at multiple time points with 3 different instruments – the AHA BLS exam, a self-efficacy survey, and a survey about the VR experience. Statistical significance could only be observed between groups for the BLS exam results at time point 2, immediately after training. There is notably a point or two increase in test scores for the intervention group when compared to the control group on the first exam and in subsequent exams this difference continued to be apparent, even without being statistically significant when analyzed through SPSS software. Because of the small sample size and the limited pool of participants, analysis using the SPSS software showed little statistical significance throughout most of this study which is disappointing, but not in a way that discourages future studies or use of VR as a viable intervention for training in CPR. The self-efficacy results all showed confidence in the performance of skills learned in both groups, but looking at the results there is a difference in that the VR participants showed slightly higher confidence levels as measured by the self-efficacy survey. There still was no statistical significance observed. Even though there is not supportive evidence to support VR as a supplemental learning tool, the research questions and hypotheses of this study should be further examined with a larger sample size to determine if there could be statistically observable effects between the two groups.

The VR survey provided some valuable information in support of using VR as a learning tool. It is important to note the positive outcomes on the VR Survey. Respondents indicated by scoring very high on the Likert scale that they would consider VR for other learning conditions, the VR experience was pleasurable, learning outcomes were satisfactory, performance was believed to be enhanced, and they would recommend VR training to others. Comments that support use of VR training included "I enjoyed using this device", "exciting, engaging, and interactive", "very cool", and "liked being able to practice with VR". Even though the BLS Exam and self-efficacy assessments did not feature any statistical significance, these qualitative comments are promising for the future of VR being used in teaching at this institution. Furthermore, follow-up comments included participants recalling actions they performed in the simulation when completing the follow-up exam and survey.

Onwuegbuzie et al. (2017) stress the importance of research that is able to build upon itself in future studies and the need for good study designs. This study provides the skeleton framework that could allow future researchers to continue the research started with this project and also allow research with other VR projects. While the power of this study was greatly limited by sample size, that power could be made greater by adding in more participants, which would help make this study more meaningful. Not only would this study have room to expand, similar studies could be undertaken by researchers and doctoral students using this framework.

Use of the CAMIL Model (Makransky & Petersen, 2021) provides a substantial advantage for using a research-based framework that will inform the field of VR in education. While this study examined self-efficacy as the main cognitive and affective factor, the model provides a great many paths that should be examined in projects that use VR for learning. Immersion, representational fidelity, and control factors are all aspects of the model on which VR developers can have an impact. Research that involves creating products that achieve greater learning outcomes benefits developers by learning exactly what works and does not work when creating VR environments, which serves to assist creators to achieve environments that are more conducive to learning. For educators, evidence of increased learning outcomes can help to make research-based teaching decisions about using VR in their teaching strategies.

Research Questions

Research Question 1

RQ1: What effect does the application of Virtual Reality as a supplement to traditional procedural training have on adult learning outcomes?

Statistical analysis between groups reveals that there is no significant effect that cannot be explained by chance occurrence of higher scores in the intervention group as measured by the BLS exam. There is evidence in the VR Survey to support the use of VR as a supplement to traditional procedural training in that participants rated the aspects of VR highly on the Likert Scale and made comments favoring the VR experience.

Research Sub-question 2

SubRQ1: How does the addition of a supplemental virtual reality simulation affect adult performance between groups in a recertification Cardiopulmonary Resuscitation (CPR) course as measured by the change in scores between an exit test and subsequent post-test comparison using the Basic Life Support certification exam?

Statistical analysis between groups as measured by independent samples *t*-tests reveals that there is no significant effect that cannot be explained by chance occurrence of higher scores in the intervention group as measured by the BLS exam taken approximately two weeks after training. The change in scores also reveals no significant difference between groups.

Research Question 2

RQ2: Does the additional modality of VR affect self-efficacy for adults in a CPR recertification course?

Statistical analysis reveals that there is no significant effect that cannot be explained by chance occurrence of higher scores in the intervention group as measured by the self-efficacy survey results. Participants were confident to perform basic life support skills, as indicated by frequent answers of 4 and 5 on the self-efficacy surveys across both groups at both time points – immediately after and two weeks after training.

Research Sub-question 2

SubRQ2: When surveyed for self-efficacy, is there a significant difference between pre, post, and follow-up change of self-efficacy scores between groups?

Statistical analysis reveals that there is no significant effect that cannot be explained by chance occurrence of higher scores in the intervention group as measured by the self-efficacy survey results. Participants were confident to perform basic life support skills, as indicated by frequent answers of 4 and 5 on the self-efficacy surveys across both groups at both time points – after and two weeks after training.

Summary of Research Questions and Hypotheses

The research questions for this study aimed to assess the effectiveness of a virtual reality simulation, "Saving Lives", added to a basic life support course. Comparisons were made between groups that completed assessment instruments at three points during the course of the study. Time point 2 revealed statistical significance between groups in favor of VR but examination of all other results reveals that, although at first glance the results seem higher in the intervention group, there is no statistical significance between these groups. Additionally, self-efficacy score changes between time points as measured between groups also did not show statistical significance.

The hypotheses and indications for this study are listed below:

Supplemental virtual reality simulation will improve CPR knowledge and skills performance in adult CPR recertification participants as measured by a test and post-test comparison as measured using the American Heart Association Basic Life Support certification exam.

Participants in the experimental group will report greater self-efficacy when surveyed two weeks after the CPR VR experience.

For time point 2, evidence is found that allows rejection of the null hypothesis. Since the statistical analysis revealed no significance for the other comparisons, the hypotheses for this study cannot be supported with this instance of research.

Limitations

Since this study recruited people who were seeking CPR re-certification, a great many did not participate in this study since they have never been certified or it had been a very long time. Finding participants at a small college is tricky and during a pandemic it proved even more difficult. The statistical power of the study would be greatly increased by using a larger sample size.

Time is always an issue when trying to gather participants for a study. I started with over 15 and ended up with 11 participants. Running more sessions would help with this limitation and should be a consideration in future research for this topic. Each class, however, requires a time commitment from both the researcher and - most importantly - the CPR instructor. The instructor taught these classes at no cost because she is a nurse educator and truly supports teaching people CPR as service to our community. However, considerations about the time commitments involved in these types of studies must be taken seriously as to not take undue advantage of the instructor's time. This study should serve as a pilot study which tests out the effectiveness of the research design and analysis.

During the course of this project, a new Oculus headset was released, which made the Oculus Go headsets obsolete since the new Quest 2 is far superior in performance. Technology moves quickly so studies of this sort must also move quickly. Unfortunately, lack of resources and the global pandemic slowed the study. Oculus Go headsets were used because they were available, but the study would be more current using newer devices. This would require purchase of the newer devices, which would require investigation of funding sources such as grants or donor funds. Since obtaining newer devices would take a great amount of time, the research was completed using the Oculus Go headsets since they are available to the researcher.

It is important to note that during the exam, participants had several questions about a few of the exam questions, which had to be clarified by the instructor. Mainly teaching and learning professionals, they have a unique perspective about exam question construction and validity. It does indicate further investigation into the efficacy of those specific questions, which is outside of the scope of this particular study.

Future Research

Although this study had many limitations, it can provide a framework for future experimental studies using virtual reality as an intervention in teaching and learning. Other researchers will be able to use the structure of the study as well as reliance on the CAMIL Model to assess effectiveness of VR applications in many areas.

Initial CPR certification with VR is a study that will be conducted at the same institution where this study occurred. This will involve teaching first time participants who have not previously completed CPR training. My hope is to integrate this into undergraduate student research that occurs frequently during student tenure at this particular institution.

Replication of this study with a larger sample size will also be an opportunity. This will provide more accurate significance as well as reduce sampling error (Field, 2018). The study can be conducted in exactly the same manner as this one but could also be adjusted as the researcher desires based on their particular research interests.

Other research paradigms could also be investigated. Studies about CPR in VR vs. online training or even use of the newer model headsets would also contribute to VR research. Being that widespread use of VR is relatively new and devices are changing at a rapid rate, the opportunity for research is great.

Since the CAMIL model was published in 2021, there are a great many opportunities to perform studies using the model so that the creators can receive feedback about the model and what it is working towards in the field of learning. This study used only one of the cognitive and affective factors that are listed in the model (self-efficacy). Other factors include interest, intrinsic motivation, embodiment, cognitive load, and self-regulation. There are in fact 22 paths that can be examined within the CAMIL framework to examine how affordance, instructional method, and modality can all interact with learning outcomes (Makransky & Petersen, 2021, p. 950). This model attempts to untangle a messy area of research in which many studies have been undertaken but an effective model had not yet been identified. Further research will help strengthen and provide dependability to the model, which will in turn help developers, educators, and most of all - students.

Conclusion

Quasi-experimental studies allow researchers to compare interventions in situations to assess whether novel innovations would be beneficial in actual real-world implementations (Cohen et al., 2011). In this study, a virtual reality simulation was examined as the intervention to see whether it had an effect on learning procedural skills and knowledge in a CPR re-certification course as measured by the standard BLS exam and a modified self-efficacy survey. Additional data was also examined to determine participant satisfaction and pleasure while using the simulation. The study provides a framework for future research that examines VR through the lens of effective implementation through the CAMIL model, which highlights that the affordances of presence and agency that are leveraged with effective instructional methods will have a positive effect on learning outcomes which are in turn related to cognitive and affective factors – measuring self-efficacy in this case (Makransky & Petersen, 2021).

It is notable that sample size has great power and in large groups, small differences in scores in large groups can have significance whereas in small groups even large differences can show no significance (Field, 2018, p. 68). It can thus be concluded that a larger sample size would be more helpful in determining more accurate significance. The value of this study rests in the fact the it provides a structure upon which future studies can be undertaken. As Onwuegbuzie et al. (2017) encourage researchers and doctoral candidates to provide transparent and detailed research strategies which are trustworthy and able to be repeated, this study will help both VR researchers and future doctoral candidates wishing to complete quasi-experimental or even other types of studies to develop sound research methodology. I hope that researchers can use this study to move even further and contribute solid information to the literature database – not only about VR but any type of research.

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APPENDIX A

BLS Certification Exam

American Heart Association
life is why

American Heart Association

Basic Life Support
Exam A

February 16, 2016

American Heart Association.
life is why™

Basic Life Support Exam A
(25 questions)

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

1. While performing high-quality CPR on an adult, what action should you ensure is being accomplished?

   A. Maintaining a compression rate of 90 to 120/min
   B. Placing hands on the upper third of the sternum
   C. Allowing the chest to recoil 1 inch
   D. Compressing to a depth of at least 2 inches

Use this scenario to answer the next 2 questions:

A 53-year-old woman collapses while gardening. She is unresponsive, is not breathing, and does not have a pulse. A neighbor, who is an emergency medical technician, rushes to her with an AED.

2. When the AED arrives, what is the first step for using it?

   A. Apply the pads to the patient's chest
   B. Clear the patient
   C. Turn on the AED
   D. Press the shock button

3. After the AED pads are attached to the victim's bare chest, the AED detects ventricular fibrillation. What is the next step when using an AED?

   A. Check the victim for a carotid pulse
   B. Follow the AED prompts
   C. Clear the patient
   D. Press the shock button

4. What should you do if you need to use an AED on someone who has been submerged in water?

   A. Do not move the victim, and do not use the AED
   B. Pull the victim out of the water, but do not use the AED
   C. Pull the victim out of the water, and wipe the chest
   D. Do not pull the victim out of the water, but wipe the chest before placing pads

5. How can rescuers ensure that they are providing effective breaths when using a bag-mask device?

   A. Observing the chest rise with breaths
   B. Delivering breaths quickly and forcefully
   C. Always having oxygen attached to the bag
   D. Allowing air to release around the mask

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6. What ratio for compressions to breaths should be used for 1-rescuer infant CPR?

   A. 5 compressions to 1 breath
   B. 20 compressions to 2 breaths
   C. 15 compressions to 2 breaths
   D. 30 compressions to 2 breaths

7. What is a consideration when you are using an AED?

   A. You should never remove a transdermal medication patch before applying AED pads
   B. On a hairy chest, the pads may not stick and may fail to deliver a shock
   C. AEDs can be used while a victim is submerged in water
   D. You should not use an AED on someone with an implanted pacemaker

Use this scenario to answer the next 2 questions:

A 9-year-old child has suddenly collapsed. After confirming that the scene is safe, a single rescuer determines that the child is in cardiac arrest, shouts for nearby help, and activates the emergency response system. He immediately begins performing high-quality CPR. Two additional rescuers arrive to assist in the resuscitation attempt.

8. What actions should occur next, to support a team-based resuscitation attempt?

   A. 2 rescuers alternate using the AED and giving breaths
   B. 1 rescuer gives CPR while the other 2 wait for advanced life support to arrive
   C. 2 rescuers alternate giving high-quality chest compressions
   D. 2 rescuers operate the AED while the third rescuer gives breaths

9. Two rescuers begin high-quality CPR while the third rescuer leaves to get the AED. What action supports 2-rescuer CPR?

   A. Alternating the AED role every 2 minutes
   B. Alternating the compressor role every 2 minutes
   C. Alternating giving rescue breaths every 3 cycles
   D. Alternating giving shocks every 3 cycles

10. "Members of the team know their boundaries and ask for help before the resuscitation attempt worsens." Match this statement with the most appropriate element of team dynamics listed.

    A. Knowledge sharing
    B. Summarizing and reevaluation
    C. Constructive intervention
    D. Knowing your limitations

11. A victim with a foreign-body airway obstruction becomes unresponsive. What is your first course of action?

    A. Start CPR, beginning with chest compressions
    B. Roll the victim over and perform back blows
    C. Perform abdominal thrusts
    D. Perform blind finger sweeps

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12. Why is defibrillation important?

    A. It prevents rearrest from occurring
    B. It is not important for cardiac arrest
    C. There is a 100% success rate in regaining a normal cardiac rhythm
    D. It can restore a regular cardiac rhythm

13. You witness someone suddenly collapse. The person is unresponsive, you hear gasping sounds, and there is no pulse. What should you do next?

    A. Begin CPR; the gasps are not normal breathing
    B. Give rescue breaths only; the gasps are not normal breathing
    C. Monitor the patient; the gasps are considered normal breathing
    D. Begin CPR, even though gasping is normal breathing

Use this scenario to answer the next 2 questions:

A middle-aged man collapses. You and a second rescuer go to the victim and find that he is unresponsive, is not breathing, and does not have a pulse.

14. Which action is most likely to positively impact this victim's survival?

    A. Performing high-quality CPR
    B. Ensuring scene safety
    C. Providing rescue breaths
    D. Checking the pulse frequently

15. You and another rescuer begin CPR. After a few cycles, you notice the chest compression rate is slowing. What should you say to offer constructive feedback?

    A. "You need to compress at a rate of 80 to 120 per minute."
    B. "You need to compress at a rate of at least 120 per minute."
    C. "You need to compress at a rate of 100 to 120 per minute."
    D. "You need to compress at a rate of at least 100 per minute."

16. How do you perform chest compressions when providing high-quality CPR to a child victim?

    A. By compressing the chest at least one third the depth of the chest, about 2 inches (5 cm)
    B. By compressing the chest at least one fourth the depth of the chest, about 1.5 inches (4 cm)
    C. By compressing the chest at least two thirds the depth of the chest, about 4 inches (10 cm)
    D. By compressing the chest at least one half the depth of the chest, about 3 inches (8 cm)

17. When performing CPR on an unresponsive choking victim, what modification should you incorporate?

    A. There are no modifications to CPR for an unresponsive choking victim
    B. You do not give breaths to an unresponsive choking victim
    C. Each time you open the airway, look for the obstructing object
    D. Attempt a jaw thrust instead of a head tilt–chin lift

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Use this scenario to answer the next 2 questions:

An 8-month-old infant is eating and suddenly begins to cough. The infant is unable to make any noise shortly after. You pick up the infant and shout for help.

18. You have determined that the infant is responsive and choking with a severe airway obstruction. How do you relieve the airway obstruction?

    A. Encourage the infant to cough
    B. Give sets of 5 back slaps and 5 chest thrusts
    C. Begin 2 thumb–encircling hands chest compressions
    D. Give abdominal thrusts

19. Which action do you perform to relieve choking in an unresponsive infant?

    A. Perform CPR, and look in the mouth for the obstructing object
    B. Give sets of 5 back slaps and 5 chest thrusts
    C. Give sets of 5 abdominal thrusts and 5 back slaps
    D. Attempt a blind finger sweep when giving breaths to remove the obstructing object

20. Which victim requires high-quality CPR?

    A. A victim who is unresponsive, has a strong pulse, and is breathing adequately
    B. A victim who is unresponsive with no normal breathing and no pulse
    C. A victim who is responsive, has a pulse, and is having trouble breathing
    D. A victim who is responsive, is having trouble breathing, and has a pulse less than 60/min

21. "The team functions smoothly when all team members know their positions, functions, and tasks during a resuscitation attempt." Match this statement with the most appropriate element of team dynamics listed.

    A. Clear roles and responsibilities
    B. Knowing your limitations
    C. Constructive intervention
    D. Mutual respect

22. Why is allowing complete chest recoil important when performing high-quality CPR?

    A. There will be a reduction of rescuer fatigue
    B. It will reduce the risk of rib fractures
    C. The heart will adequately refill between compressions
    D. The rate of chest compressions will increase

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Use this scenario to answer the next 2 questions:

A 67-year-old man is found unresponsive, not breathing, and without a pulse. You and a second rescuer begin performing high-quality CPR.

23. When should rescuers switch positions during CPR?

    A. Never switch rescuers, and maintain current roles
    B. Switch rescuers at 5-minute intervals
    C. Switch rescuers about every 2 minutes
    D. Switch rescuers when placing the AED pads

24. You notice the person giving chest compressions is not allowing for complete chest recoil. What is your next course of action?

    A. Stand back and await direction from the team leader
    B. Take over leadership and give direction
    C. Immediately take over chest compressions
    D. Tell the compressor you notice decreased chest recoil

25. Rapid defibrillation is a link in the adult Chain of Survival. Why is this important to survival?

    A. It prevents cardiac arrest
    B. It prevents respiratory arrest
    C. It provides normal respiration
    D. It eliminates the abnormal heart rhythm

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Student Answer Sheet
Basic Life Support Exam

Name: ______________________ Date: ____________________ Version: _____

Question	Answer			
1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D
11.	A	B	C	D
12.	A	B	C	D
13.	A	B	C	D
14.	A	B	C	D
15.	A	B	C	D
16.	A	B	C	D
17.	A	B	C	D
18.	A	B	C	D
19.	A	B	C	D
20.	A	B	C	D
21.	A	B	C	D
22.	A	B	C	D
23.	A	B	C	D
24.	A	B	C	D
25.	A	B	C	D

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Answer Key
Basic Life Support Exam A

Question	Answer			
1.	A	B	C	•
2.	A	B	•	D
3.	A	•	C	D
4.	A	B	•	D
5.	•	B	C	D
6.	A	B	C	•
7.	A	•	C	D
8.	A	B	•	D
9.	A	•	C	D
10.	A	B	C	•
11.	•	B	C	D
12.	A	B	C	•
13.	•	B	C	D
14.	•	B	C	D
15.	A	B	•	D
16.	•	B	C	D
17.	A	B	•	D
18.	A	•	C	D
19.	•	B	C	D
20.	A	•	C	D
21.	•	B	C	D
22.	A	B	•	D
23.	A	B	•	D
24.	A	B	C	•
25.	A	B	C	•

APPENDIX B

Self-efficacy Survey

This survey was available via Google form or on paper (if the participant prefers a hard copy). Questions are to be answered on a 1-5 Likert Scale, with one being disagree and five being agree.

1. I feel confident in my ability to perform CPR.
2. I would be able to check if a person can breathe independently.
3. I can practice chest compressions correctly.
4. I would be able to understand when a person has regained vital functions.
5. I can practice chest compressions without losing time.

This survey was created by adapting the self-efficacy questions posed in by Buttussi et al. (2020).

APPENDIX C

Demographic and CPR Experience Information

These items are for demographic purposes.

1. Are you currently CPR certified?
    a. Yes
    b. No
2. When was your last CPR training and certification completed?
    a. Between 2-3 years ago
    b. Between 3-4 years ago
    c. Between 4-5 years ago
    d. 5-10 years ago

- How long have you been CPR certified (in years)?
- What is your date of birth?
- What is your occupation?
- Why are you renewing CPR certification?

APPENDIX D

Virtual Reality Post-survey

Only Administer to Intervention Group

This survey was available via Google form or on paper (if the participant prefers a hard copy).

Short Answer Items

4. Do you have any previous VR experience?
5. Do you own a VR headset?
6. Please comment on the VR experience in as much detail as possible (pros and cons).

Likert Scale Items

Questions to be answered on a 1-5 Likert Scale: 1 is disagree and five is agree.

7. After this experience, I would consider using VR for other learning experiences.
8. The VR experience was pleasurable for me.
9. I was satisfied with the outcome of training using VR practice for CPR recertification.
10. The VR experience enhanced my performance on the BLS Certification exam.
11. I would have preferred more time with the VR headset.
12. I would have preferred more time with the mannequin.
13. I would recommend VR training to others.

APPENDIX E

Recruitment Instrument

Participation Invitation Email Subject:

Request to Participate in Doctoral Study: Immersive Learning in Education for CPR Skills Acquisition.

Email Body:

Dear [member],

My name is Ayra Sundbom. I am a doctoral student in the Instructional Systems Design & Technology Program at Sam Houston State University. I am seeking participants in a doctoral research study that I am conducting titled: Immersive Learning in Education for CPR Skills Acquisition. The purpose of this mixed-methods study is to assess the efficacy and student satisfaction of using immersive learning environments to learn CPR skills in a classroom setting in addition to a learning mannequin. Participants should have been certified in CPR within the past ten years and eligible for recertification through the American Heart Association. Your participation would be a valuable contribution to this study.

Participation in the study involves:

- Completion of the BLS re-certification course, self-efficacy survey, and examination
- Completion of a self-efficacy survey and the examination again two weeks after the initial examination

The attached document describes the study in greater detail. Your participation is entirely voluntary, and you may withdraw from the study at any time. The study is completely confidential; no names or other identifying information will be used when reporting data. If you would like to participate, please respond directly to this email. Thank you for your consideration!

Kind Regards, Ayra Sundbom

Project Description (attachment)

Project Title

Immersive learning in education for CPR skills acquisition

Purpose

The purpose of this study is to assess the efficacy and student satisfaction of using immersive learning environments to learn CPR skills in a classroom setting in addition to a learning mannequin.

Procedures

Surveys and assessment scores will be used to analyze this VR learning environment's effectiveness compared to the traditional learning methods.

Risks

The participant may experience slight discomfort, such as nausea or dizziness when using the VR headset.

Benefits

Practitioners will gain insight into how immersive learning and VR can be effectively implemented into their teaching strategies.

Confidentiality

Results of the study may be published, but no names or identifying information will be included in the publication. Data will be de-identified before reporting. Survey data will only be reported as an aggregate. The data will be securely stored in a university-approved virtual location compliant with institutional data privacy standards. Only the researchers will have access to the information stored electronically without any identifying information, and it will be destroyed three years from the completion of the study.

Investigators

Ayra D. Sundbom, PI and Doctoral Candidate (Sam Houston State University)

Elizabeth Gross, Student Advisor, Assistant Professor, Instructional Systems Design & Technology, Sam Houston State University

APPENDIX F

SHSU IRB Approval

Date: 4-20-2022

IRB #: IRB-2022-2
Title: Immersive Learning in Education for CPR Skills Acquisition
Creation Date: 1-5-2022
End Date:
Status: Approved
Principal Investigator: Ayra Sundbom
Review Board: SHSU IRB
Sponsor:

Study History

Submission Type	Initial	Review Type	Expedited	Decision	Approved

Key Study Contacts

Member	Elizabeth Gross	Role	Co-Principal Investigator	Contact	eag041@shsu.edu
Member	Ayra Sundbom	Role	Principal Investigator	Contact	ads086@shsu.edu
Member	Ayra Sundbom	Role	Primary Contact	Contact	ads086@shsu.edu

APPENDIX G

NCWC IRB Approval Letter

March 22, 2022

Dear Ms. Sundbom,

The Institutional Review Board of North Carolina Wesleyan College has reviewed your study, titled "Immersive Learning in Education for CPR Skills Acquisition" and has found that the proposed methodology for this study adheres to the ethical standards in human research regulations of the Department of Health and Human Services policy 45CFR 46. Therefore, it is approved to move forward.

Please notify the NCWC IRB in writing if adverse events occur, or if there is a change in research methodology, or new subjects are recruited who do not meet the description of subjects in the proposal. If the collection of data should extend beyond your expected timeline, please send a letter to me indicating the current status of the project and whether any changes have been made to the protocol.

Sincerely,

IRB Chair

North Carolina Wesleyan College
Phone:
Email:

APPENDIX H

Oculus Go Instructions to Access Saving Lives App

Oculus Go Instructions

- ☑ Turn on the Go and place headset on your head. Adjust straps as needed.
- ☑ Follow instructions to enter the virtual environment by holding the Oculus button.
- ☑ On the menu, select navigate, then library, then unknown sources.
- ☑ Select the file to open: "com.ilx.savinglives".
- ☑ Once in the app, select layperson mode.
- ☑ Save the life of the virtual patient with your CPR knowledge anfd skills.
- ☑ Ask for help if you need it!
- ☑ View the startup video with this link or QR: https://youtu.be/P8fEgAnMcCQ

Parts of the Go

1. Headset
2. Controller
3. Power Button
4. Volume Control
5. Charging Port
6. Trigger
7. Oculus Button
8. Back Button
9. Touchpad

VITA

AYRA SUNDBOM

Education

Current: Doctoral in Education in Instructional Systems Design & TechnologySam Houston State University, Huntsville, TX

2015 Master of Science in Instructional Design

Saint Leo University, Saint Leo, FL

2011 Health Information Technology Workforce Training Program

Pitt Community College, Winterville, NC

2004 Bachelor of Science in Computer Information Systems, Cum Laude

Saint Leo University, Saint Leo, FL

Professional Experience

North Carolina Wesleyan College, Rocky Mount NC

Instructional Technologist ***2016-current***

- Training and support of faculty and staff for Jenzabar, Starfish, Instructional Technology Software, Universal Design for Learning, and any other technology need
- Website design and maintenance for the Teaching and Learning Center
- Media production of college presentations and scholarly events

- Development of educational resources for faculty and students
- Transformation of traditional courses and training sessions into online learning applications
- Assist Director and Assistant Director of Teaching and Learning with events, research, and faculty and staff support
- Serve as administrator of Turnitin and Starfish programs
- Advise students in the Business Program

Pitt Community College, Greenville NC

Part-Time Instructor, Arts & Sciences Division ***2015-current***

- Training and support of faculty and staff for MS Office, Moodle, Turnitin, Instructional Technology Software, and Respondus
- Website design and maintenance for the Office of Teaching and Learning, The Division of Arts and Sciences, PCC Global, and Title III Grant
- Curriculum design for ADA compliance course for PCC employees
- Transformation of traditional courses and training sessions into online learning applications
- Assist Director of Teaching and Learning with events, research, and faculty and staff support

Administrative Assistant, Arts and Sciences Division **2013-2016**

- Administrative and technical support for the division required organizational, communication, and people skills with superb attention to detail

- Training and support of faculty and staff for Moodle and Respondus
- Data analysis to promote divisional objectives through the use of Informer, Colleague, and other resources
- Coordination of processes to maximize efficiency on a global level, such as automation of missed class processes and centralization of duties, where indicated
- Coordination of Arts & Sciences web content
- Training and support of divisional administrative staff in seven departments
- Coordination with payroll, HR, purchasing, scheduling, and student services
- Facilitation of training and customer service opportunities for divisional advisors and staff (i.e., outreach to students through online videos and presentations for advising purposes)
- Facilitation of compliance with federal, state, and local regulations and standards
- Assist in divisional budget management, including travel, equipment, and purchasing
- Research information for learning outcomes definition, analysis, and assessment
- Organization of events for both students and staff
- Collaborate with colleagues campus-wide to streamline processes and design instruction
- Serve on the PCC Employee Excellence Fund Drive Steering Committee 2014 & 2015
- PCC Staff Excellence Award 2015
- Way to Success Coach

Eckerd Corporation, Largo FL ***2001-2005***

Senior Human Resources Services Coordinator / HR Analyst

- Data management and analysis: Peoplesoft database of over 75,000+ associates
- Development of Human Resources/Training reports for internal and external customers
- Database administration: field reports for national, regional, district, and individual retail needs for training, diversity, and compliance purposes
- Compliance with company policy and governmental entities
- Development of ad-hoc data reports and query development for specialized needs
- Managed Human Resources IT aspects of corporate office closure and reassignment of employees
- Preparation of administrative reports via PeopleSoft to assess hierarchy and chain of command
- Managed confidentiality of personnel records according to appropriate guidelines/law

Senior Human Resources Coordinator

- Coordinator for associates' leave of absence, insurance, payroll, and other HR issues
- Designed and implemented an electronic system of insurance billing processes for associates on leave
- Maintenance and administration of the leave of absence departmental database
- Assessment and resolution of disability payroll issues

- Problem resolution and management of insurance billing and insurance coverage
- Ensuring compliance with FMLA, COBRA, and HIPAA laws

Courses Developed or Taught at North Carolina Wesleyan College

Undergraduate Full Semester Courses

2017-2022 COL 103 Transfer Transition Success

2020-2022 EDU 310 Technology in Education

Faculty Development Asynchronous Online Courses

2017-2020 Basic Jenzabar Elearning Training (JET)

2018-2020 Advanced Jenzabar Elearning Training (JET)

2019-2020 Universal Design for Learning (UDL)

2020 Video Production for Teaching

2020 Immersive Learning Experience Design with Incite VR

Training Sessions and Solutions

2019 Virtual Adjunct Faculty Convocation

2017-2020 Electronic Resources at NCWC for the Summer Bridge Program

2016-2019 Starfish Retention Software

2016-2022 Jenzabar exi Advising Software

2016-2022 Training on classroom technology, including short-throw projectors and casting

2015-2022 Turnitin Originality Software

Presentations

10/13/17 Attended and presented at Kikofest: “Power Up”

10/20/17 Attended and co-presented at North Carolina Library Association with Ian Boucher: “An Augmented Reality Scavenger Hunt for First Year Undergraduate Students”

10/24/17 EDU 310, 9 students (with Ian Boucher on Augmented Reality)

11/2/17 Attended and presented at NCCCSPA: “It’s All Fun and Games Until….”

11/9/17 EDU 310, 8 students (with Ian Boucher on Virtual Reality)

2016-2018 Google Expeditions with Communities in Schools program, about 60 8th grade students and 4 teachers

1/6/19 Presented to resident advisors about environmental sustainability

Memberships and Service

2016-2021 Ex-oficio member of the NCWC Faculty Technology Committee

2019-2021 Students Advocating for Gender Acceptance (SAGA) Co-Advisor

2017-2021 The NCWC B Club (bees, birds, bats, butterflies, beasts...) Advisor

2017-2020 Leadership Wesleyan Mentor

2018-2018 VR Trivia Assistant for Battle of the Bishops

2018-2021 St. Lewis 4H Club Leader

2016-2020 International Society for Technology in Education Member

2017-2019 International Kiko Goat Association Board Member and Backup Webmaster

2012-2022 Bearadise Farm Co-owner

2016-2017 Advisory Board Member for the East Carolina Livestock Show and Sale

2018-2021 Game Judge for Serious Play Conference Awards

2021-2024 Edgecombe County Soil and Water Conservation District Supervisor

2021-2023 Advisory Board Member for the East Carolina Livestock Show and Sale

2020-2022 Bearadise Farm memorandum of understanding practical site for Nash Community College Vet Tech Program.

Involvement in Projects

2020-2021 NCWC Office of Undergraduate Research Development Committee

2020 Member of the Reopening Committee at NCWC

2020 NCWC Strategic Planning-Theme Team for Student Success

2019 Gamification of faculty professional development for the Teaching & Learning Center

2018 Turnitin Integration Team

2018 Created video with Dr. Jonathan Sarris about *Reacting to the Past*

2018 Assisted the NCWC Exercise Science Department with the FITwise research study data collection

2017 Makerspace research and creation assistance at NCWC Library with library staff

2017-2019 Google Expeditions implementation into Religious Studies courses with Dr. Jung Choi

2016-2020 Teaching and Learning Center YouTube Manager

Publications

1/10/17 “VR FOR ALL SEASONS!” with Ian Boucher