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16. Abstract

Immersive Virtual Learning Environments (IVLEs) are extensively used in training, but few rigorous scientific investigations regarding the transfer of learning have been conducted. Measurement of learning transfer through evaluative methods is key for determining the likelihood of equivalent performance post-training intervention. Research has shown that immersive virtual learning environments are advantageous for training psychomotor activities and spatial activities, but it is unclear whether these environments are beneficial for memorizing a procedure. More important than the IVLE technology is the ability of IVLEs to provide higher critical thinking to learners. IVLEs are often implemented through the use of game-based technology, which is argued to hold the promise for fostering critical thinking skills and other 21st century skills.

The role of a highway flagman is one that involves high-order problem solving and decision making skills due to variables, such as weather conditions, traffic complexity, multifaceted geographic settings, and multiple lane intersections, that impact a flagman's final decisions regarding construction and/or maintenance work zone design and implementation. For this reason, it is critical for flaggers to receive highly transferable training so they can perform to the best of their ability. This research tested the use of an IVLE simulating real-world highway work zones. IVLEs go beyond traditional visual learning by presenting images that combine a new form of visual learning and virtual-experiential learning in a way that is more congruent with an individual's visual images stored in memory, thus improving knowledge transfer and retention. The visual cues that the learner experiences in the virtual world are so similar to the visual cues in the real world that recall of virtual world lessons stored in memory are triggered by the same cues in the real world. Additionally, the student can experiment, make mistakes, and repeat the activity as often as necessary, achieving a virtual-experiential understanding of the concept that can only be duplicated in real-world experiential learning, which is often not practical. Such immersive engagement in the learning activity will allow the learners to move beyond the memorization of the presented concepts and into the application and synthesis of the material.

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Evaluation of Knowledge Transfer in an Immersive Virtual Learning Environment for the Transportation Community

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Rationale

In the year 2009 alone, 667 individuals were killed in the United States in highway construction or maintenance work zones. More alarmingly, the total number of individuals killed in a highway construction or maintenance work zone in the U.S. since 2003 is a staggering 6,438 (National Work Zone Safety Information Clearinghouse, 2010). The Louisiana Department of Transportation and Development (DOTD) defined a highway construction or maintenance work zone as an area of highway with maintenance, construction, or utility work activities (DOTD, 2010). This type of work zone is normally marked by temporary traffic control devices such as signs, channeling devices, barriers, pavement markings, and/or work vehicles. Working in a highway construction or maintenance work zone is a highly physical activity that requires extreme focus, planning, and process implementation (Louisiana Department of Transportation and Development, 2010).

An Immersive Virtual Learning Environment (IVLE) is an environment that encompasses the user in a real- life, simulated environment (Savin-Badden, 2008). This environment capitalizes on natural aspects of human perception by extending the virtual information in three spatial dimensions, supplementing information with other stimuli and temporal changes, and enabling individuals to interact with the displayed data (Dalgarno & Lee, 2010).

Use of IVLE technology may aid in decreasing the number of work zone fatalities that occur each year by allowing active experimentation in a highway construction or maintenance work zone to occur in a safe and supportive learning environment. Active experimentation within an IVLE will allow learners the opportunity to apply work zone regulations and procedures in a realistic, although simulated, environment. Unlike the real world, a mistake in this virtual environment will not result in the loss of life. Studies indicated that adult learners are more apt to apply encoded instructional knowledge in the IVLE because mistakes can be made without negative consequences, encouraging application and building confidence (Blumel, Termath, & Haase, 2009). Dede (2000) highlighted that simulation and visualization tools, like an IVLE, can aid students in recognizing patterns, reasoning about physical processes, translating within frames of reference, and envisioning dynamic models.

This research tested the use of 3D technology in an IVLE, which simulated real-world highway work zones. The IVLE supplemented traditional course content and delivery methods to enhance the transfer of work zone safety procedure knowledge. This learning environment consisted of real-life case studies within a 3D virtual world. The research was unique due to the evaluation of the effectiveness of knowledge transfer across a diverse population of learners that had not yet been studied as it relates to IVLE implementation in the classroom. This research expanded the scientific knowledge of adult education involving knowledge transfer in an IVLE; specifically, that an IVLE may enhance and supplement traditional learning through blended delivery methodology when utilized in a classroom environment with a diverse learner population.

Purpose of Study

The purpose of this research study was to determine if an IVLE increased the learning transfer of the knowledge obtained in a work zone safety Basic Flagging Procedures course. Studies have shown that learner engagement is paramount to learning success (Lim, Nonis, & Hedberg, 2006). This project hoped to find that through the IVLE, learning engagement was increased as the learners were fully integrated into the work zone safety simulation, with a specific focus on flagging procedures, as though they were actually performing the prescribed duties in accordance with the required rules and procedures. Such engagement in the learning activity allowed the learners to move beyond the memorization of the presented concepts and into the application and synthesis of the material.

As supported by Kolb's (1984) Experiential Learning Theory, the IVLE allowed the adult learners to move from the concrete experience (current knowledge of work zone safety flagging procedures) to reflective observation (reflection on current knowledge of work zone safety flagging procedures as it relate to new materials) to abstract conceptualization (the application of the new knowledge of work zone safety flagging procedures) and lastly to active experimentation (constructing new methods for using the new information on the job) (Swanson & Holton, 2001).

Blumel et al. (2009) stated that any organization's goal should be to provide suitable qualification measures to prepare employees for impending tasks before a new project begins. This study sought to achieve this goal by preparing transportation employees for the utilization of flagging procedures in work zones via the blended delivery method of the IVLE. By allowing the learners to explore flagging procedures as they related to work zone safety through an IVLE, the achieved success of the executable tasks connected to this environment will be evaluated as the measure as to the effectiveness of the IVLE (Blumel et al., 2009). This study did not ask "What can the IVLE do?" but rather "What is the IVLE doing?" (Ellaway, Dewhurst, & McLeod, 2004).

Research Question

This study aimed to answer the question: Is an IVLE a more effective method than the traditional method for delivering the procedural content in the "Basic Flagging Procedures" course to aid in the imprinting of the concepts presented regarding maintenance and construction work zones?

Independent and Dependent Variables

The independent variables in this study were: whether or not the students participated in the traditional or immersive virtual learning environment Basic Flagging Procedures course; education level; years working in highway construction; age; race; and gender. The dependent variables will be: success rate on posttest and precision within the IVLE.

Objectives

The objectives for this research study were as follows:

1. To describe the adult learners that attended the Basic Flagging Procedures course in the southern region of the United States on the following demographic characteristics
    a) Race
    b) Gender
    c) Age
    d) Highest educational level completed
    e) Years worked as an adult (18 years old and older)
    f) Years worked in highway maintenance or construction
    g) Previous flagger course taken or not
    h) Type of organization
    i) Current job title
    j) Total income in previous year;
2. To compare the traditional course delivery method to the IVLE course delivery method based on pre and posttest scores;
3. To determine the precision of participants while in the IVLE through the use of telemetry data;
4. To examine the differences in the pre-telemetry measurements to the post-telemetry measurements; and

5. To determine if a model exists which would explain a significant portion of variance in overall scale score.

Limitations

Within this research study, there were two limitations to address:

1. A portion of the population has taken this course content previously, thus exposing them to the material and the test prior to this study.
2. Population was limited to participants in the southern portion of Louisiana.

Significance of the Study

This research will contribute fundamentally to the research of an IVLE not only as it relates to the transportation community but also to the research of the marginalized population. The hypothesis that the use of 3D technology to create an IVLE in order to increase the transfer of learning has been evaluated in a number of fields with the findings as to its success varying across the disciplines (Blascovich, Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002; Clarke & Dede, 2005; de Freitas & Oliver, 2006; Jarmon, Traphagan, & Mayrath, 2008). However, the aforementioned studies were conducted with homogenous groups, with this aspect being a fundamental difference in this research study. This project was comprised of a truly heterogeneous group on many levels (e.g. years of experience, technological proficiency, formal education, age, gender, etc.). Research conducted with extremely diverse populations increases generalizability to other populations and aids in supporting that individuals with limited technological skills so they can succeed scholastically in an environment with learning technology.

The prototype of blended learning utilized in this research project was very specific, but the knowledge gained and the technology developed from this research will have far-reaching impacts for any training where realistic practice is difficult and where realism during training is invaluable. This research will expand the current empirical knowledge of a virtual learning environment in education, specifically that which deals with knowledge transfer in an IVLE as it enhances and supplements traditional learning through blended delivery methodology. The type of training will transcend subgroups, reduce the intergroup achievement gap, and increase participation due to the similarity to massive multiplayer online games, resulting in more students being better prepared for further educational opportunities and careers.

The IVLE also adds an avenue for increasing the knowledge and skill level of the marginalized population. Through the use of this blended methodology, the marginalized population was presented with technological advances in the realm of education that previously may have not been within their reach. By exposing this population to this type of educational element, a decrease in training resistance may be found. If a decrease in training resistance occurs, the likelihood of learning transfer increases, thus leading to a better-trained population.

Definition of Terms

For the purpose of this research study, the following definitions are offered to assist in the understanding of terminology as it relates to this study:

1. Immersive Virtual Learning Environment: An environment that encompasses the user in a real- life, simulated environment (Savin-Badden, 2008). This environment capitalizes on natural aspects of human perception by extending the virtual information in three spatial dimensions, supplements information with other stimuli and temporal changes, and enables individuals to interact with the displayed data (Dalgarno & Lee, 2010).
2. Presence: The subjective experiences of being in one place or environment despite physically being situated in another (Witmer & Singer, 1998).
3. Marginalized Population: A portion of the population that is excluded, trivialized, devalued, or relegated to an unimportant or powerless position within a group or society (Merriam-Webster, 2008).
4. Education: "The fundamental method of social progress and reform; a regulation of the process of coming to share in the social consciousness; and that the adjustment of individual activity on the basis of this social consciousness is the only sure method of social reconstruction" (p. 453, Dewey in McDermott, 1981).
5. Avatar: A representation of a person in a virtual environment (Bailenson, Blascovich, Beall, & Noveck, 2006).
6. Socioeconomic Status: An individual's economic position relative to others, based on income, education, and occupation (Merriam-Webster, 2008). Socioeconomic status is used interchangeably with the category "Total Income in the Previous Year," as indicated in the demographic survey.
7. Course Definition: The "Basic Flagging Procedures" course is designed to offer participants information that is necessary to move vehicles and pedestrians safely and quickly through or around temporary traffic control

zones while protecting on-site workers and equipment. Traffic regulation is a pivotal and essential duty of traffic control operations. The role of a traffic regulator/flagger is crucial to the success and safety of well-run traffic operations (Louisiana Transportation Research Center, 2010).

8. Louisiana Department of Transportation and Development: The Louisiana agency that is responsible for the maintenance of state roadways, bridges, etc. (Louisiana Department of Transportation and Development, 2010).
9. Local Government: Any parish government entity that is not the DOTD but receives primary funding from taxpayer dollars.
10. Private Industry: Any entity that is not the federal, state, or local government.
11. Precision: The degree of refinement with which an operation is performed or a measurement stated (Merriam-Webster, 2008).
12. Louisiana Transportation Research Center: "Created by the legislature in 1986, the Louisiana Transportation Research Center (LTRC) conducts short-term and long-term research and provides technology assistance, engineering training and continuing education, technology transfer, and problem-solving services to the DOTD and others in the transportation community. The center is largely supported by funding authorized by the Federal Highway Administration. LTRC's goal is to merge the resources of state government and universities to identify, develop, and implement new technology to improve the state's transportation system. LTRC combines the efforts of DOTD and the state's universities to find innovative solutions to Louisiana's transportation problems" (pp. 1-2).

A History of Distance Education

Sumner (2000) stated, "Technology has always had an intimate relationship with distance education because it mediates the separation between teacher and learner through the use of print, radio, telephone, television, audio and videotapes, and computers." Prewitt (1998) highlighted that two primary forces through history have driven distance education: the need for increased and more democratic access to learning and the availability of successive new technologies for delivery. Casey (2008) stated that distance education has flourished in the United States for three reasons:

1. The great distances of citizens from educational institutions, both geographically and socio-economically;
2. The thirst for education; and

3. The rapid advancement of technology.

Beginning in the 19th century in terms of correspondence study, distance education is well documented (Sumner, 2000). The first documented distance education course was the Pittman Shorthand training program in 1852 (Casey, 2008). Anna Eliot Ticknor founded the Society to Encourage Study at Home in 1873 in an effort to encourage continued education, with a primary female clientele, but this program provided correspondence instruction to 10,000 members over the course of a 24-year period (Casey, 2008; Sumner, 2000). In addition, the University of Chicago created the first collegiate level distance learning program in 1892, which was supported by the United States Post Office through free delivery service (Prewitt, 1998; Casey, 2008). Despite distance education having three centuries of historical roots, it is still met by skepticism primarily with concerns of quality control (Casey, 2008).

In the early part of the 20th century, such correspondence study was prevalent in universities and private schools (Sumner, 2000). By 1921, the University of Salt Lake City, the University of Wisconsin, and the University of Minnesota had been granted the first educational radio licenses (Casey, 2008; Sumner, 2000). With two World Wars, the field of distance education grew profoundly, and the armed services demanded correspondence education for soldiers during World War I and viewed correspondence study as a way to change society after World War II and the Great Depression (Holmberg, 1986, as cited in Sumner, 2000). The use of two-way communication was employed through the integration of broadcast media, cassettes, and some computers (Casey, 2008; Nipper, 1989). The use of televisions as an instructional tool began in 1934 with the University of Iowa (Casey, 2008). The Instructional Television Fixed Service (ITFS) was created by the Federal Communications Commission (FCC) to provide 20 television channels that were available to education institutions for providing a low-cost, fixed-range, subscriber-based system to broadcast courses (Casey, 2008).

The University of Wisconsin continued to be a leader in distance education as they created the Articulated Instructional Media (AIM) Project in 1964, with the goal to identify, categorize, and systemize distance learning practices while offering direction on how to develop and implement instructional multimedia components to best suit the learner (Casey, 2008). Distance learning was not only flourishing in the United States but abroad as well. The British Open University was established in 1969 based upon a blueprint from the AIM Project to further distance education and has continued to be a leader in the field of distance education (Casey, 2008; Sumner, 2000). The British Open University currently provides 21% of higher education in England and provides a standard for others in the distance learning community (Casey, 2008).

Coastline Community College created, licensed, and implemented the first fully televised college courses in 1970 (Casey, 2008). Unique to Coastline Community College is that it had no actual college campus. Other universities across the United States followed the example set by Coastline Community College, and by 1972 colleges in Miami, FL; Costa Mesa, CA; and Dallas, TX became pioneers in televised college courses (Casey, 2008). Such televised courses sought to recreate traditional classroom settings while providing educational opportunities to an innumerable amount of learners (Prewitt, 1998). Bringing distance education to yet another level, the use of satellite communication was integrated into primarily the business community in the beginning stages during the 1980s (Casey, 2008). Although satellite television was created during the 1960s, it only began being utilized as an educational medium in the 1980s. The National Technological University (NTU) began offering online degree courses in 1982 for continuing and graduate education using satellite technology (Casey, 2008). This type of educational technology promoted system-serving forms of distance education to include: professional accreditation, military training, human resource development, and collegiate courses (Sumner, 2000).

Quite possibly the most significant impact on the field of distance education is that of the World Wide Web, created by Tim Berners-Lee in 1991 (Casey, 2008). The web has provided a platform for online academic instruction, sharing of scholarly data, and providing a plethora of online degree programs. The web has also provided the opportunity for an array of technological advances in the field of distance education, leading to vast opportunities for academic institutions to better meet students' instructional needs (Casey, 2008).

Transactional Distance Education

Transactional distance, as explained by Moore (1993), occurs between teachers and learners in an environment having the special characteristic of separation of teachers from learners. Moore (1993) also highlighted that this separation leads to special patterns of teacher and learner behaviors, which has a significant impact on teaching and learning. Moore (1993) stated, "With separation there is a psychological and communications space to be crossed, a space of potential misunderstanding between the inputs of the instructor and those of the learner. It is this psychological and communications space that is transactional distance" (p. 1). Communication and psychological spaces between learners and teachers are never identical, thus, transactional distance is a continuous rather than finite, a concept that is relative rather than an absolute (Moore, 1993).

Moore (1993) posited that for successful distance education to occur is dependent upon the institution and the instructor providing appropriate opportunities for dialogue between the teacher and learner. To distinguish dialogue from interaction, Moore (1993) asserted that dialogue is used to describe an interaction or series of interactions that possess positive qualities that other interactions may not have. Furthermore, Moore (1993) stated, "A dialogue is purposeful, constructive, and valued by each party. Each party in a dialogue is a respectful and active listener; each is a contributor, and builds on the contributions of the other party or parties" (p. 2).

Saba (2007) articulated the relationship between structure and dialogue as they relate to transactional distance education. Saba (2007) presented the following hypothesis as it relates to transactional distance, "(a) [W]hen structure increases, transactional distance increases and dialog decreases; (b) [W]hen dialog increases, transactional distance decreases and structure decreases" (p. 45). Peters (2007) asserted that Moore's theory of transactional distance is primarily descriptive in that it does not recommend a specific model of learning and teaching at a distance; however, the theory describes three teaching behaviors: dialogue, structure, and autonomy (Peters, 2007). The theory of transactional distance suggests that distance education should be comprised of these three teaching – learning behaviors, which denotes Moore's desire to innovate and improve distance education and online learning (Peters, 2007). Through his description of dialogue, structure, and autonomy as fundamental components of distance education, Moore provided the resources for improving distance education and enhancing its pedagogical quality (Peters, 2007). Transactional distance theory, as stated by Moore (2007), allows for innumerable hypotheses for research into the following: interactions between course structure, dialogue between students and teacher, and students' propensity to exercise control of the learning process.

As evidenced in the above literature, distance education has a storied history from the early vocational training of factory workers to current collegiate academic programs (Casey, 2008). Further highlighting the power of distance education, Galusha (1998) stated, "The teacher is no longer the sole source of knowledge but instead becomes a facilitator to support student learning, while the student actively participates in what and how the knowledge is imparted. More than any other teaching method, distance learning requires a collaborative effort between student and teacher, unbounded by the traditional limits of time, space, and single-instructor effort" (p. 4). Technology in distance education is powerful, dynamic, and enriches learning in which time and geographic location disappear (Miltiadou & Savenye, 2003).

Immersive Virtual Learning Environments

The purpose of any learning approach is to achieve the learning objectives set out in the delivered course and ensuring the learning objectives are designed into the created course content (Selim, 2005). Online education is a subcategory of distance education that offers educational alternatives and provides life-long learning opportunities for those that a traditional learning environment may not work or be possible (Miltiadou & Savenye, 2003). Online education can provide both synchronous and asynchronous learning opportunities. Miltiadou and Savenye (2003) defined synchronous learning opportunities as, “[I]nteraction [that] allows students and instructors to exchange ideas and discuss course topics at the same time through a virtual discussion area” (p. 3). Miltiadou and Savenye (2003) went on to define asynchronous learning opportunities as, “[I]nteraction [that] provides opportunities for active input from all members of the online classroom and supports learner-centered learning environments” (p. 3). In order to expand upon the traditional online learning environment, the virtual learning environment can provide a means for building upon an already solid instructional base. An immersive virtual learning environment, a “fully integrated virtual world,” can offer learning institutions the opportunity to improve “passive distance education” through increased communication, interaction, and learning activities (Schrum & Hong, 2002, p. 58).

Ellaway (2005) stated, “The use of technology-supported teaching and learning in higher education has moved from a position of peripheral interest a few years ago to become a fundamental ingredient in the experience of many if not most students today” (p. 1). The immersive virtual learning environment combines a host of tools and resources into a single system (Ellaway, 2005). Technology provides a means for enabling students to master more complex subjects via significant interactions with resources that extend beyond the traditional classroom walls (Dede, 2000). Dede (2000) stated, “[T]echnology enhanced curricular approaches improve success for all types of learners and may differentially enhance the performance of at-risk students” (p. 1). Although the population in this study is not defined as “at risk,” they are a population that is considered marginalized and often left behind in educational research due to presumptions of their inability to succeed in a classroom setting. Nonetheless, the design and implementation of an immersive virtual learning environment must be realized through careful design of the learning environment and informed through an analysis of the critical characteristics that enhance learning (Herrington, Reeves, Oliver, & Woo, 2004).

According to Hobbs, Brown, and Gordon (2006), current practice in higher education is moving away from didactic content delivery to a student-centered model with an increasing emphasis on the skills that support independent, self-directed learning. Virtual worlds provide this type of independent, self-directed learning (Hobbs et al. 2006). It is essential for educators to investigate innovative and engaging teaching methodologies to offer a more fulfilling learning experience (Cobb, Heany, Corcoran, & Henderson-Begg, 2009). Echoed by Jarmon, Traphagn, and Mayrath (2008), they indicated that the use of virtual worlds can enhance student motivation and engagement, which provides for social interaction, collaboration, increased sense of shared presence, exploration, and creation. Jarmon et al. (2008) also stated that few empirical studies document learning within virtual worlds. Educators involved with employing groundbreaking pedagogies and curricular are often viewed as innovators and are willing to challenge the boundaries of traditional practices (Dede, 1998). Immersive learning is not new but rather dates back to the days of apprenticeships and distributed education (Johnson & Levine, 2008). Implementation of an IVLE with a marginalized population challenges the traditional educational boundaries while still incorporating historically successful principles of the past (Johnson & Levine, 2008).

The effectiveness and value of an IVLE is not inherent to the IVLE software or platform but rather depends on its use in facilitating and mediating the needs and activities of the instructional material (Ellaway, Dewhurst, & McLeod, 2004). The question to be addressed regarding an IVLE is not "What can it do?" but rather "What is it doing?" (Ellaway et al., 2004, p. 127). IVLE functions exist in a blended relationship with other human activities, independent of whether they are the primary delivery medium or among one of many (Ellaway et al., 2004). The use of an IVLE in adult education offers advantages over learning through real-life practice, as described in the forthcoming sections (Savin-Badden, 2008).

Virtual worlds seem to provide an ideal vehicle for providing learners with "lived experiences," while meeting the needs of individuals and society in the 21st century (Twining, 2009, p. 498). Twining (2009) highlighted that a virtual world will allow for the following:

- Experiencing things that would be difficult or impossible to do in the physical world – both physically and pragmatically.
- Experiences in virtual worlds suggest that these are spaces, which encourage playfulness and test boundaries (p. 498).

These "lived experiences" are enhanced through the principle of immersion within the learning environment (Twining, 2009, p. 498). Witmer and Singer (1994) defined immersion as the subjective impression that one is participating in a comprehensive, realistic experience. Clarke and Dede (2005) expanded upon this concept by highlighting that immersion is a "mediated, simulated experiment (such as a virtual environment) which involves the willing suspension of disbelief" (p. 2). The IVLE provides this suspension of disbelief while engaging the learners in a realistic, meaningful context (Herrington, Reeves, & Oliver, 2007). Such suspension of disbelief provides a method for preparing individuals for the necessary recognition of key aspects of tasks associated with real world activities (Clarke & Dede, 2005).

Mestre (2002) presented the following question, “How can education prepare people to recognize the cues that signal application of appropriate knowledge?” (p. 9). Mestre (2002) went on to state that cues in the problem or environment govern the retrieval of prior information which aids in the transfer and application of the knowledge. Dalgarno and Lee (2010) provided an affordance of an IVLE that states, “3-D VLEs can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualization of learning” (p. 21). The contextualized learning is where the cues are provided that aid the learner in applying the appropriate knowledge post learning, which is a key benefit of an IVLE.

A study conducted by the Computing Research Association and the International Society of Learning Sciences in 2005 highlighted that one of the main challenges facing educators is moving from the dominant view of technology being disruptive in the classroom to understanding how to utilize the benefits that technology has to offer within the classroom. The Computing Research Association and the International Society of Learning Sciences (2005) also identified that simulations and models provide insights into scientific concepts and phenomena. However, they did note that a challenge is to lay scientific and technical groundwork to ensure that these simulations positively impact learning, thus limiting the potential negative or distracting impacts.

If an IVLE is designed correctly, the distracting factors can be removed. A key to a well-designed IVLE is expounded upon by Pannese and Carlesi (2007),

> If correctly designed, which means that the real working environment needs to be studied in order to reproduce it in the protected simulation environment, this form of exercise offers another double potential: the exercises are repeatable (with the same or slightly different conditions, should something be worth being reconsidered) and at the same time, every simulation experience is unique, as every experience in life is unqiue! On the other hand, serious games are simultaneously very close to reality (if designed as such) and multisituational as difference aspects of the same situation can be experienced (p. 440).

Properly designed IVLEs, which can be considered serious games, can provide the flexibility and useful knowledge necessary to provide contextualized and anchored learning (Kiili, 2007).

Learning in an IVLE allows for exposure to a wide range of scenarios at a time and pace convenient to the learner while allowing for consistent feedback. The IVLE offers the learner chances to make mistakes without real-world repercussions, but it allows for the virtual-world repercussions to be experienced in a non-threatening environment (Savin-Badden, 2008). An IVLE also offers an opportunity for collaboration where appropriate, as well as offering new opportunities for review of abstract concepts (Savin-Badden, 2008).

Kramer and Schmidt (2001) identified the potential role of technology in education for reconstructing education and learning:

- The same content can be presented using different media types.
- Different perspectives and access to the same topic can be used to provide cognitive flexibility.
- Education software development and knowledge modeling tools facilitate authoring of multimedia education material and technology.
- Interaction provides learners with opportunities for experimentation, context-dependent feedback, and constructive problem solving.
- Asynchronous and synchronous communication and collaboration helps bridge geographical distance.
- Virtual laboratories and environments can be used to offer near authentic situations and opportunities for hands-on experimentation and problem solving.
- Operation sequences and preferred learning paths can be recorded and evaluated (p. 196).

To further support the above-mentioned points, Whitelock, Romano, Jelfs, and Brna (2000) reiterated that an IVLE allows learners to enter a new world that they might not otherwise get to experience. The learners no longer have to be passive spectators in their learning experience but can manipulate their learning environment in a number of ways (Whitelock et al., 2000).

As identified by Clark and Mayer (2003), instruction through an e-lesson (in this study, an IVLE), must guide the learner's transformation of words and pictures through the sensory and working memories in order for this information to be integrated into the existing knowledge base in long-term memory. For this to occur, Clark and Mayer (2003) noted that the following must transpire:

- Selection of the important information in the course.
- Management of the limited capacity in working memory to allow the rehearsal needed for learning.
- Integration of auditory and visual sensory information in working memory with existing knowledge in long-term memory by way of rehearsal in working memory.
- Retrieval of new knowledge and skills from long – term memory into working memory when needed later.

- Management of all of these processes via metacognitive skills.

Clark and Mayer (2003) added that for learning transfer to occur, these e-lessons must incorporate the context of the job by offering concrete examples to take the abstract concepts into reality. Blumel et al. (2009) reiterated Clark and Mayer's (2003) position as they stated, "Realistically representing and precisely visualizing the operations facilitates comprehension and hones the ability to transfer practiced procedures to a real work situation" (p. 6).

Kapp and O'Driscoll (2010) indicated that that an IVLE offers generative learning, providing meaning and insight that challenges the status quo. In order to challenge this status quo, Kapp and O'Driscoll (2010) asserted that although content is critical in developing an effective traditional course context is now the domain when it relates to an IVLE. To further emphasize the pervasiveness of IVLEs, Kapp and O'Driscoll (2010) claimed,

> The transformation of the web from a static, one-way conduit of information into a three-dimensional world where people, as avatars, interact, work, and collaborate virtually has undoubtedly arrived. Those who embrace the Immersive Internet to transform the learning experience will thrive, while those who ignore it will become increasingly marginalized by the businesses or students they serve (p. 44).

Blascovich, Loomis, Beall, Swinth, Hoyt, and Bailenson (2002) further stated that, "Virtual worlds are simply synthetic representations of real or imagined physical worlds, albeit without the physical laws of nature necessarily applying" (p. 107). The three-dimensional IVLE provides the "sense of being there" and provides mental and visual cues that "make recall and application of the learning" obtained in the IVLE more effective (Kapp & O'Driscoll, 2010, p. 44). This sense of being there was expounded in the literature as the philosophy of presence (Kapp & O'Driscoll, 2010).

Witmer and Singer (1998) posited there are some necessary conditions for presence to occur: involvement and immersion. Witmer and Singer (1998) defined involvement as it relates to a virtual environment as:

> [A] psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events. In general, as users focus more attention on the VE [virtual environment] stimuli, they become more involved in the VE experence, which leads to an increased sense of presence in the VE (p. 227).

To build upon the definition of involvement as it relates to presence in an IVLE, Witmer and Singer (1998) continued on to define immersion as:

> [A] psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. A VE that produces a greater sense of immersion will produce higher levels of presence. Factors that affect immersion include isolation from the physical environment, perception of inclusion in the VE, natural modes of interaction and control, and perception of self-movement (p. 227).

Blascovich et al. (2002) provided that IVLEs hold the promise to increase the actual presence and could hold the key to obscuring the distinction between face-to-face and "electronically mediated social interaction" (p. 111). Persky, Kaphingst, McCall, Lachance, Beall, and Blascovich (2009) defined presence as,"[P]resence is understood as perceiving as reality the VE as opposed to the physical environment encompassing the VE" (p.263). Arguably, Kapp and O'Driscoll (2010), Witmer and Singer (1998), and Blacscovich et al. (2002) each asserted that presence is a critical element for a student in order for engagement in the IVLE to not only occur but to effectively occur.

Relating to the principle of engagement, Kapp and O'Driscoll (2010) argued that engagement is a function of interactivity multiplied by immersion as denoted below:

$$I * I = E$$

The philosophy Kapp and O'Driscoll (2010) presented as it relates to engagement claimed that the learner becomes an active participant in the IVLE. In the IVLE the learning is no longer "disembodied and transactional" but is rather "embodied and experiential" (p. 63). This embodied and experiential learning, according to Kapp and O'Driscoll (2010) allows for, "…the learner to more effectively encode the learning for future recall and provides the cues needed to apply the experience from the 3D world to actual on-the-job performance. In short, [IVLEs] are the ultimate 'learning by doing' platform" (p. 63).

A taxonomy of student engagement developed by Bangert-Drowns and Pyke (2001) presented a progressive, seven-level matrix to aid in the evaluation of "behavioral indicators" of engagement. These levels are not hierarchical and do not define determinants for engagement, but the levels do provide a guide for determining the level of engagement of the learner (Bangert-Drowns & Pyke, 2001; Lim, Nonis, & Hedberg, 2006). Table 1, found in Appendix 1, presented this taxonomy of engagement. Determining the level at which the learner is engaged aids in evaluating the overall success of the learning event (Bangert-Drowns & Pyke, 2001). Bangert-Drowns and Pyke (2001) stated, "The taxonomy evolved as a means to describe, not explain, different modes of engagement…The taxonomy of student engagement may be useful for teaching students to identify and initiate appropriate modes of engagement in particular learning and software contexts" (p. 23).

With educational technology, there are varying levels of using the technology in the classroom. An IVLE can be categorized as a simulation that provides a method for modeling a real-world simulation on the computer (de Freitas, 2006). As de Freitas (2006) indicated, IVLEs or simulations can be used to motivate and engage learners, specifically the underserved groups with low literacy and language levels. Also indicated by de Freitas (2006), utilization of an IVLE can allow for skill rehearsal, advance real-life practice, and provide therapy for cognitive difficulties. In order to ensure engagement and to achieve the maximum benefit from immersion in a virtual learning environment, utilizing a framework for the design and support of the process is critical to the IVLEs success. The Four Dimensional Framework presented by de Freitas and Oliver (2006) offer the following four dimensions in terms of selecting and using educational technology in practice: context, learner specification, representation, and pedagogic model or approach used.

The context of the educational technology is central to the effectiveness of how the game is used (de Freitas, 2006; de Freitas & Oliver, 2006). The context includes where the technology is used, the general environment for game play, and the socio-political context of the technology (de Freitas, 2006). Identifying the learner specifications includes aspects such as age, educational background, demographics, previous technology use, and previous learning experiences (de Freitas, 2006). Representation of the educational technology includes the level of immersion and fidelity of the game. Lastly, the pedagogic model or approach used addresses that the learning technology is rarely an isolated learning experience but is rather embedded within a set of activities or processes according to a specific pedagogical approach used, most often Kolb's (1984) experiential learning (de Freitas & Oliver, 2006; Kolb, 1984). This framework offered a beginning point for educators considering using immersive technology in the learning process (de Freitas & Oliver, 2006). Such a framework provides an effective guide for the field of adult education.

Adult Education

Andragogy, as defined by Knowles (1980), is the art and science of helping adults learn, in contrast to pedagogy as the art and science of teaching children. European adult educators coined the word andragogy (circa 1833) as they felt a need to have a label for the new model of adult education. Andragogy is based on the Greek work *aner* with the stem *andr-* which means "man, not boy" or adult (Knowles, 1980). Knowles (1980) himself argued that andragogy is an integrative concept. In Knowles' book *Informal Adult Education* (1950), he presented 13 principles of adult teaching:

- Students should understand and prescribe to the purpose of the course
- Students should want to learn
- The learning climate should be friendly and informal
- The physical conditions should be favorable
- Students should participate and accept some responsibility for the learning process
- Learning should be related to and should make use of students' experience
- The teacher should know his/her subject matter
- The teacher should be enthusiastic about subject being taught
- Students should be able to learn at their own pace
- Students should be aware of their progress and have sense of accomplishment
- Methods of instruction should be varied
- The teacher should have a sense of growth
- The teacher should have a flexible plan for the course

A characteristic common to most of these principles is called "ego-involvement" (p. 36). According to Knowles (1950),

> Ego-involvement is the condition in which a person completely identifies himself—his goals, his values, his interests—with whatever he and his fellow students are doing. He [She] becomes involved with this to the extent of losing himself [herself] in it (p. 36).

Axford (1969) described the adult education process as "one that must be woven into the fabric of our institutional pattern of living. Continuing education must be made as natural as brushing our teeth" (p. 57). Axford (1969) said the "ideal" adult educator must have the following qualities: be a humane human being, have a nose for needs, be an organizer, be flexible, be a sharer of ideas, be a philosopher of adult education, be a promoter of adult education, be a trainer, be involved, be a leader, be a program planner/catalyst, one who practices what he preaches, have thick skin, and be committed to the adult learning process. All of these characteristics are part of a model of the "ideal adult educator"; however, possessing these qualities is only the beginning of being a successful adult educator. One must also understand the adult learner.

The adult learner is different than the traditional student. To understand the adult learner, educators must be aware of three points: adults have more experiences, adults have different kinds of experiences, and adults' experiences are organized differently (Axford, 1969). Adults' experiences drastically vary from those of a child (Knowles, 1950). That being said, adults hold mental models that shape their learning experiences whereas a child comes to the educational experience with few preconceived notions (Knowles, 1950). Therefore, the adult educator is partly responsible for engaging the adult learner in the double-loop learning process in order for alterations within their deeply held image to occur (Axford, 1969).

Is teaching an adult really different? Teaching adults should be different if adults learn differently than children do. Knowles, Holton, and Swanson's (2005) core assumptions of andragogy evolved from four to six, as indicated below:

- The Need to Know: Adults want to know why they need to learn something before undertaking learning. Adult educators must understand the learners' desires to know why they should learn, thus making a case for why the learning is important (Knowles et al., 2005).
- The Learners' Self-Concept: Adults believe they are responsible for their lives (Knowles et al., 2005). Adult learners need to be viewed as capable individuals who are a driving force in their learning.
- The Role of the Learners' Experiences: Adults come into an educational activity with different experiences than do youth (Knowles et al., 2005; Merriam & Caffarella, 2007). Adult learners' experiences are some of the richest tools an adult educator can utilize. However, just as these experiences are rich, they can also be a detriment to the learning experience if they are not utilized properly.
- Readiness to Learn: Adults become ready to learn things they need to know and do in order to cope effectively with real-life situations (Knowles et al., 2005). Adults want to learn how they can utilize the learned information in the present. Although they tend to realize the learning impacts the future, they want to see how they can make the most expeditious use of the learned material(s).
- Orientation to Learning: Adults are life-centered (task-centered, problem-centered) in their orientation to learning (Knowles et al., 2005). They want to learn what will help them perform tasks or deal with problems they confront in their actual life, both personally and professionally (Merriam & Caffarella, 2007).
- Motivation: Adults are responsive to some external motivators, but the most potent motivators are internal. While many adults will claim that the external motivators are the real motivation, if there is no intrinsic value to the learning than the likelihood of learning occurring substantially decreases (Knowles et al., 2005).

A study conducted by Bale and Dudney (2000) revolved around Knowles' core assumptions, which are stated above. Bale and Dudney (2000) set out to discern whether or not adult learners preferred the andragogical approach to teaching adults. During this study, Bale and Dudney (2000) utilized the Student Orientation Questionnaire created by Christian (1982) to closely fit

Knowles' assumptions of adult learners, which was an adaptation of the Educational Orientation Questionnaire created by Hadley (1975). Through using this questionnaire, Bale and Dudney (2000) were able to identify that traditional college-age students prefer a hybrid approach to teaching and learning in the classroom, which included the principle of empowerment.

Freire (1972) incorporated the theory of empowerment into his view of education. Coming from an oppressed background, Freire (1972) saw that power was shared, and that the power of many allow for strength and purpose to lead to a common vision. Shared power in learning is exercised in control over curriculum, its contents and methods, and the coordination of all learning activities (Freire, 1972). Just as Knowles (1984) and Axford (1969) have stated, Freire (1972) concurred that the adult learner must be seen as a decision maker in the learning process. Freire (1972) stated that literacy and other basic skills can be acquired at an astonishing speed when the fostering of these skills is linked with other activities.

Understanding the Adult Learner

Along with understanding the adult educator comes the responsibility of understanding the psychology of the adult (Knowles et al., 2005). Programs are often based on what an individual or small group thinks or ought to be interested in rather than on what the learners really need or want to know (Knowles, 1950). Possibly the most important factor for adult educators to realize is that adults are very different from one another (Merriam & Caffarella, 2007). Each adult comes to learning experiences with different life experiences, different prejudices, different fears, etc.; adults have motivating forces that drive them to the educational experience. These motivational forces are as follows: physical needs, growth urge, need for security, need for new experience, need for affection, and the need for recognition (Knowles, 1950). These needs are natural, and each adult experiences a need for one or all of these motivational forces. It is crucial that adult educators illuminate the importance to adult learners that these needs be met (Knowles, 1950; Merriam & Caffarella, 2007). The suppression of such desires will lead to fear of education or damage to one's personality (Freire, 1972). The purpose of the teacher is to guide the process of learning that will be meaningful to the student. The teacher is to guide the student through developing his/her own natural potential (Knowles, 1950). Therefore, it is the duty of the teacher to select and organize the teaching material to allow natural potential in students to grow. Vella (2002) claimed that for effective adult learning to occur, dialogue must be included in the learning process.

The mission of the adult educator is to describe three distinct sets of needs and goals: needs and goals of individuals, needs and goals of the institution, and needs and goals of society (Knowles, 1980). It is the instructor's mission to help individuals learn what is required for success in whatever need they are struggling (i.e. job placement, job satisfaction, etc…). Institutions also have needs and goals that help define the adult educator's mission. These needs and goals are to be met if the learning process is to succeed. The societal goal implies that the betterment of adults will foster the betterment of society as well (Knowles, 1950; Freire, 1972).

Holton and Swanson (2001) stated that, "The goal of transfer [of learning] is the full application of new knowledge and skills to improve individual and/or group performance in an organization of community" (p. 245). The first place transfer of learning should take place is within the classroom. Transference is most likely to occur in the subsequent situations: association, similarity, degree of original learning, and critical attribute element (Leib, 1991). Leib (1991) defined association as a learner's ability to associate the new information with something they already know. He labeled similarity as the learner's ability to take the new information and apply it to similar incidents, which results in a logical pattern. Leib (1991) described the degree of logical learning simply as the fact that the learner's original degree of learning was high. Lastly, Leib (1991) depicted a critical attribute element as the information learned that contains elements which are extremely beneficial on the job.

A study by Miller in 1956 indicated that the amount of information that can be remembered in one exposure is between five and nine times depending on the information. This concept became known as "Miller's Magic Number." The critical aspect of this principle is the connection between a learner's short-term memory (STM) and their long-term memory (LTM) (Miller, 1956). As adult educators, it is critical that learning is relevant and meaningful to ensure that the transfer of information from STM to LTM occurs (Miller, 1956). However, there are negative and positive types of learning transfer. Positive transference occurs when the learners use the behaviors taught in the course (Leib, 1991). Negative transference occurs when the learners do not use the behaviors taught in the course (Leib, 1991). Without a solid foundation upon which to base the practice of adult education, achieving goals can be quite difficult (Knowles et al. 2005; Merriam & Caffarella, 2007; Miller, 1956).

Experiential Learning in the Immersive Virtual Learning Environment

According to Kolb (1984), "Learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it" (p. 41). Kolb (1984) called this perspective on learning "experiential" for the following reasons. The first reason is to link "experiential" learning to the works of John Dewey, Kurt Lewin, and Jean Piaget, and the second reason is to call attention to the importance that experience plays in the learning process (Kolb, 1984). As Kolb said, “This differentiates experiential learning theory from rationalist and other cognitive theories of learning that tend to give primary emphasis to acquisition, manipulation, and recall of abstract symbols, and from behavioral learning theories that deny any role for consciousness and subjective experience in the learning process” (p. 20). Kolb (1984) posited experiential learning as a “holistic” perspective on learning that combines “experience, perception, cognition, and behavior” (p. 20).

While Kolb (1984) is one of the most well-known scholars in the field of experiential learning, he drew upon the works of John Dewey, Kurt Lewin, and Jean Piaget in the development of his theory of experiential learning. The work of Dewey is one of the most influential relating to the guiding principles for experiential learning (Kolb, 1984). Dewey proposed that education be designed on the basis of a theory of experience (Kolb, 1984). This theory of experience posited two central systems of belief: continuity and interaction (Kolb, 1984). The presentation of continuity suggests that humans are affected by experience, which is critical for obtaining the skills necessary for living in “society.” Dewey asserted that humans learn from each experience whether it is positive or negative; these experiences have a critical impact on future experiences (Kolb, 1984). Continuity lies in the concept that these experiences are stored and carried into the future whether one desires this to occur or not (Kolb, 1984). The concept of interaction builds upon the theory of continuity and offers an explanation of how past experiences interact with the current/present situation (Kolb, 1984). Dewey asserted that the present experience interacts with the past experience to create the current experience. These systems of belief offer a rationale as to how to individuals can experience situations in profoundly unique manners due to the function of continuity and interaction (Kolb, 1984).

Lewin stated that learning is “best facilitated in an environment where there is dialectic tension and conflict between immediate, concrete experience and analytic detachment” (Kolb, 1984, p. 9). Lewin stated that, “By bringing together immediate experiences of the learner and the conceptual models of the staff in an open atmosphere where inputs from each perspective could challenge and stimulate the other, a learning environment occurred with remarkable vitality and creativity” (Kolb, 1984, p. 10). Lewin and his colleagues can be credited with creating the groundwork for two influential “streams of development” that are critical to experiential learning: values and technology (Kolb, 1984). T-groups and the laboratory method provided a focus on the value of “subjective personal experience in learning,” which contrasts the traditional behaviorist theories, most notably that of Skinner (Kolb, 1984). Kolb (1984) stated of Lewin’s work, “This emphasis on subjective experience has developed into a strong commitment in the practice of experiential learning to existential values of personal involvement, and responsibility and humanistic values emphasizing that feelings as well as thoughts are facts” (p. 11). Just as important as this focus on values was the expanding technology for applied learning. Lewin (as cited in Kolb, 1984) presented that the focus of the technologies was a simulated situation that was designed to create personal experiences understanding. This concept reverberated through adult education theory, as can be seen in the works of Knowles.

Piaget's theory described how intelligence is "shaped" by experience (Kolb, 1984). Kolb (1984) said of Piaget's theory that, "Intelligence is not an innate internal characteristic of the individual but arises as a product of the interaction between the person and his or her environment. And for Piaget, action is the key" (p. 12). The work of Bruner in America was parallel to the work of Piaget and aided in a movement in curriculum development and teaching that focused on "the design of experience-based educational programs using the principles of cognitive-development theory" (Kolb, 1984, p. 12). Much of Bruner's work consisted of modifications to Piaget's original work. In both Piaget and Bruner's work, the results of their experiments echoed that of Lewin's that, when children were "freed from the lockstep pace of memorization," they excelled in the discovery of knowledge, not just in the content (Kolb, 1984). This same notion of the learner being "freed" during the learning experience continues to translate into adult education theory and practice (Kolb, 1984).

Kolb (1984) asserted there are many similarities between Dewey, Lewin, and Piaget's viewpoints on the learning process. Kolb (1984) presented that experiential learning has six key characteristics, which are shared by Dewey, Lewin, and Piaget as well:

- Learning is best conceived as a process, not in terms of outcomes.
- Learning is a continuous process grounded in experience.
- The process of learning requires the resolution of conflicts between dialectically opposed modes of adaption to the world.
- Learning is a holistic process of adaption to the world.
- Learning involves transactions between the person and the environment.
- Learning is the process of creating knowledge.

Based upon these six characteristics, Kolb (1984) outlined the following regarding the process of learning:

- The emphasis is on the process of adaptation and learning rather than content or outcomes.
- Knowledge is a transformation process that is continuously created and recreated, not independently acquired or transmitted.
- Learning transforms experience in both objective and subjective forms.

- To understand learning, one must understand the nature of knowledge and vice versa.

The experiential learning model presented by Kolb (1984) can be described as a four-stage cycle with four "adaptive learning modes" – concrete experience, reflective observation, abstract conceptualization, and active experimentation. Kolb (1984) described the four "adaptive learning modes" in the following manner:

- Concrete Experience – learning by experiencing; learning from specific experiences; relating to others; being sensitive to feelings and people.
- Reflective Observation – learning by reflecting; observing before making judgments; viewing things from other perspectives; looking for the meaning of things.
- Abstract Conceptualization – learning by thinking; analyzing ideas logically; planning systematically; acting on an intellectual understanding of a situation.
- Active Experimentation – learning by doing; displaying the ability to get things accomplished; taking risks; influencing people and events through action.

This experiential model presented by Kolb (1984) contained two distinct modes of gaining experience that are related to each other: concrete experience (*apprehension*) and abstract conceptualization (*comprehension*) (Oxendine, Robinson, & Willson, 2004). In addition, there are also two distinct methods of transforming the experience: reflective observation (*intension*) and active experimentation (*extension*) (Baker, Jensen, & Kolb, 2005). These four modes create the four-stage experiential learning cycle presented below.

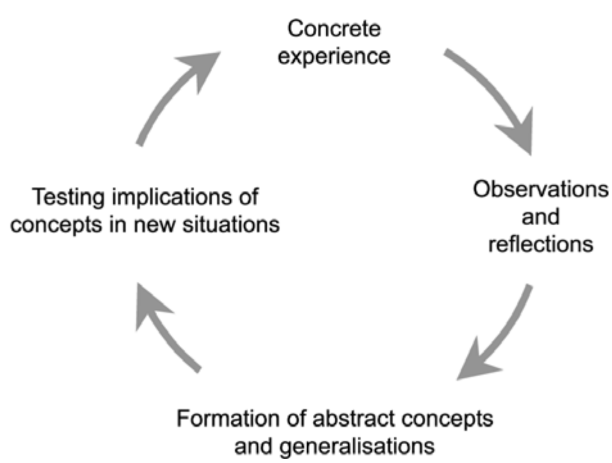

Figure 1
David A. Kolb's Experiential Learning Model – 1984

At the beginning of the experience learning cycle, the learners start with concrete experience, which transitions them into reflecting upon their experience. Once the learners have reflected, they enter abstract conceptualization by creating ideas for use in forthcoming events (Kolb, 1984; Oxendine et al., 2004). Oxendine et al. (2004) stated, regarding active experimentation, "With these guides in place, the learners actively test what they have constructed leading to new experiences and the renewing of the learning cycle" (p. 4). Apprehension-Comprehension is a continuum that involves the transformation of experience; one without the other is not an effective means for acquiring knowledge (Baker et al., 2005). The Intension-Extension represents the "transformation" of the experience (Baker et al., 2005). Baker et al. (2002) argued that to transform the experience something must be "done with it," (the experience) because "perception alone is not sufficient for learning" (p. 417).

Oxendine et al. (2004) presented the following steps for integrating experiential learning into the classroom:

1. Set up the experience by introducing learners to the topic and covering basic material that the learner must know beforehand.
2. Engage the learner in a realistic experience that provides intrigue as well as depth of involvement.
3. Allow for discussion of the experience, including the happenings that occurred and how the individuals involved felt.
4. The learner will then begin to formulate concepts and hypotheses concerning the experience through discussion as well as individual reflection.
5. Allow the learners to experiment with their newly formed concepts and experiences.
6. Further reflection on experimentation (pp. 1).

Utilizing these steps during a simulation process, like an IVLE, created a "direct experience" for the learner (Oxendine et al., 2004). This direct experience coincided with the experiential learning process presented by Kolb (1984).

Learning by doing, through experiential learning, is a fundamental platform for IVLEs, and Hew and Cheung (2010) highlighted that, in following Kolb's experiential learning cycle concept, users in an IVLE can act upon the objects which allows them to learn by doing, observe the results of their actions, test their assumptions about the situation, and reflect on their understanding. Dede (1995) noted that the virtual world environment provides the arena for students to "learn by doing" through a real-world representation of the desired environment. As with any training or educational intervention, an IVLE is only as effective as the skills that are transferred (Waller, Hunt, & Knapp, 1998). Hawk and Shah (2007) further expounded on Kolb's experiential learning by averring that learning is a "holistic set of processes that are continuous" and supported through an IVLE (p. 3). An IVLE allows a learner to complete Kolb's cycle of experiential learning on a continual basis and is a reflection of the fact that the virtual world, like the real world, must be learned before it can be exploited (Johnson & Levine, 2008). Jarmon et al. (2008) recommended that experiential learning be the foundation of any IVLE.

IVLEs provide an effective environment for bridging education and experience, which suggests that this type of environment is "optimal" for experiential learning to occur (Jarmon, Traphagan, Mayrath, & Trivedi, 2009). Jarmon et al. (2009) continued to state that experiential learning in an IVLE allows learners to demonstrate their learning through the creation of real-life problem solving, real-life project creation, and collaboration in a virtual world. There are six facets identified by Jarmon et al. (2009) that facilitate experiential learning in an IVLE:

1. The capacity to host virtual social interactions and collaborations.
2. The capacity to allow users to test hypotheses by applying them to an actual project and doing something active without the risk and cost of the real world.
3. The possibilities for relevance of their virtual actions in the real world.
4. The capacity to allow for various types of abilities to be practiced and demonstrated virtually.
5. The simulation of imagination, exploration, and creativity.
6. An increased sense of personal presence and tangible experience in the virtual world (p. 175).

Jarmon et al. (2009) further stated, "The sense of embodiment in [an IVLE] helped make their [the students] experiences in the virtual environment real and fostered their sense of concrete experiences. This sense of embodied social presence initiated and enhanced the experiential learning cycle" (p. 179).

Thomas and Brown (2009) asserted that, in an IVLE, learners are able to implement new behaviors, repeat the behaviors to gain experience, observe the outcome, and adjust future behavior based on the outcomes. Through this process, potentially significant and long-lasting behavior changes can occur (Brown & Thomas, 2009). The ultimate objective of providing an IVLE to learners is to assist in the development and improvement of real-world skills (Cobb, Neale, & Reynolds, 1998). Through an IVLE, learners no longer have to be "passive spectators" in the learning process but can experience and manipulate the presented real-world scenarios in a variety of ways (Persky et al., 2009; Whitelock et al., 2000).

As with experiential learning, the emphasis within constructivism is on a learner's ability to solve "real-life problems" (Huang, 2002). Dewey (1916) posited the teacher as a "guide" of learning rather than a "director" of learning. Jonassen (2000, as cited in Huang, (2002) indicated that learners can use technology in constructivist learning environments to:

1. Articulate what they know.
2. Reflect on what they have learned.
3. Support the internal negotiation of meaning making.
4. Construct personal representations of meaning.
5. Support intentional, mindful thinking.

Huang (2002) continued to assert that the appropriate type of technology can aid in facilitating learning if the appropriate choice of material and technology is made. In addition to asserting that the technology choice must be appropriate to ensure effectiveness, Huang (2002) also reinforced the position that the learning experience must be authentic and meet real life experiences. Jonassen (2008) argued, "If schools are to foster meaningful learning, then the ways that we use technologies in schools must change from technology-as-teacher to technology-as-partner in the learning process" (p. 7).

METHODOLOGY

Project Creation and Collaboration

This research project was conducted through a collaborative effort between a state department of transportation (DOT) and two universities located in the southeastern portion of the United States. The researcher at the state DOT and two universities designed the immersive virtual learning environment (IVLE). The researcher accomplished the tasks of project management, instructional design, context and content development, scripting, technological design, and day-to-day administration, in a fashion similar to that described by Kapp and O'Driscoll (2010).

Upon completion of an intense review of literature, the researcher created a problem statement to drive the research study and worked with the subject matter experts to ensure the IVLE development and implementation supported the purpose of the research study. Over the course of six months, the researcher worked closely to ensure the IVLE supported the instructional material and research purpose while still creating an extraordinary IVLE. Another phase of the project collaboration was to include key players from the state DOT in the pilot testing of the IVLE in the classroom. Those individuals from the state DOT that participated in the formal pilot testing included: state DOT trainers, state DOT work zone safety specialists, state DOT engineers, and state DOT instructional designers. The pilot testing included two formal class deliveries which implemented the IVLE into the course along with 10 additional pilot testing meetings between researcher and the design team.

This design involved an experimental and control group that are both administered pre and posttests; however, these groups are not randomly selected because they constitute naturally assembled groups (Campbell & Stanley, 1963). Participants received a pretest at the start of the class and a posttest upon class completion. Pretests are beneficial in this design because "they tell us about how the groups being compared initially differ and so alert us to the higher probability that some internal validity threats rather than others may be operating" (Shadish, Cook, & Campbell, 2002, p. 136). Shadish et al. (2002) went on to say that "the strong assumption is that the smaller the difference on the pretest, the less is the likelihood of strong initial selection biases on that pretest operating …" but they cautioned that other unmeasured variables that exist at the time of the pretest may influence the outcome (p. 136).

Population and Sample

The target population for this research is public (state and local government) and private highway maintenance workers. The accessible population consisted of those workers in the greater metropolitan area of a large southern United States city.

Research Implementation

First, a determination was made as to how many classes of 24 students per class could be held, and what days the training facilities would be available. This resulted in a total of 15 classes and provided a training opportunity for a maximum of 360 subjects. The researcher randomly assigned experimental or control designation to each of the 15 classes, resulting in eight experimental and seven control classes. This random assignment of the groups to the levels of the treatment was completed through the flip of a coin. Only the researcher knew class designation (i.e. experimental or control), thus participants would not know if they were attending an experimental or control class prior to the start of the class.

Consequently, participants' only prior knowledge was that they were attending a flagger safety course. Training managers from public and private organizations in the region were briefed ahead of time that the Basic Flagger Course was being offered, and they were told that some classes would supplement the existing instruction with the new training technology and that others would not. The training managers were assured both classes (control and experimental) would meet the training need, the objectives identified in the course, and that the overall quality of either type of class would not suffer. In addition, they were asked not to discuss the different delivery methods with class participants. The training managers were provided a schedule of the classes and asked to appoint students to the classes on a first-come, first-serve basis. The researcher confirmed attendance with the training managers and then sent a reminder of the schedule approximately 72 hours prior to the class.

The lecture was presented by the same individual for all classes, thus minimizing error due to presentation. The computer skills needed by the participants were minimal; participants operated within the IVLE using one simple input device, similar to those commonly utilized with serious games (e.g. PlayStation 3®, Xbox®). Participants saw themselves as avatars in the IVLE and were able to move their avatars to perform specific flagging training tasks. A robust tracking system was embedded in the software to track the spatial (x-y-z coordinates) and temporal movement of the avatar of each participant. A highly precise and redundant telegraphy data storage system (both hardware and protocol) was developed to allow easy retrieval of the working data for subsequent statistical analysis use by the researchers only. Development of the protocols took place early in the design phase and considered data integrity as well as report generation requirements.

In addition to this data, quantitative data was generated for each student while in the IVLE. These data consisted of spatial (x-y-z coordinate mapped movements) and temporal (time to execute movements) data. These data were used to plot the precision of the subject's solution to problems presented in the IVLE, indicating understanding of the underlying abstract taught concept. Also, these data were used to plot the change in performance over the course of the class indicating how well the subject improved his or her performance while in the IVLE. The impending findings from this data will be presented in forthcoming papers and conferences.

Finally, qualitative data was collected to assess the affective response of the subjects to the IVLE. After each treatment class, four or five subjects volunteered to take part in an interview (n = 32). Review of the data indicated an extremely positive reaction to the IVLE by the subjects. All empirical data were subjected to the appropriate statistical tests, including measures of central tendency about the mean.

Data Collection

Data were collected from six sources. The data collection instruments and methods approved by the appropriate Institutional Review Board are as follows:

1. Literature Review
2. Demographic Survey
3. Pretest
4. Posttest
5. IVLE Telegraphy
6. Qualitative Interviews

Literature Review

Although little is currently published regarding the science of applying an IVLE to a diverse group of adult learners, a great deal of published research existed for IVLEs in general, pedagogy in the virtual world, children and young adults learning in the virtual world, and virtual world design (Kapp & O'Driscoll, 2010).

Demographic Survey

The demographic survey instrument (Appendix 2) was intentionally brief and gathered pertinent information such as age, gender, ethnicity, education level, socio-economic status, and current job title. The coded demographic survey instrument is located in Appendix 3.

Pretest/Posttest

The pretest/posttest were equivalent (Appendix 4 and 5). The purpose of the pretest was to reveal pre-training baseline understanding of flagger techniques and abstract concepts. The posttest was designed evaluate learning transfer.

IVLE Telemetry

A robust tracking system was embedded in the software to track and measure every one-tenth of a second, the spatial (x-y-z coordinates) and temporal movement of the avatar of each participant. A highly precise and redundant telegraphy data storage system (both hardware and protocol) was developed to allow easy retrieval of the working data for subsequent statistical analysis use by the researcher only.

Qualitative Interview

Four to five volunteers from each treatment class participated in one-on-one interviews at the completion of the class, resulting in a total of 32 interviews. Each interviewer, as supervised by the researcher, used the same list of open-ended questions (Appendix 6) and was encouraged to use probing questions whenever the opportunity was present. Interviewers observed all treatment class subjects during the course via closed circuit television to discover behavior such as collaborative efforts and perceived body language. All interviewers had participated in a graduate-level qualitative research methods course that included effective interview techniques.

Institutional Review Board Approval

The researchers completed the *NIH Office of Extramural Research Protecting Human Research Participants* online course and all assessment instruments have been approved by the LSU Institutional Review Board (HE10-4).

DISCUSSION OF RESULTS

Overview of Findings

Both a qualitative and quantitative analysis was performed at the conclusion of the experiment. Demographic data for the combined treatment and control groups (n = 305) indicated that of those responding, the majority of the sample was African-American (64.3%) and that 88.3% were males. It is interesting to note that 76% of the sample had a high school degree, GED, or less, and that the largest group of individuals was between the ages of 46 to 64 years (46.6%) of age and had never attended a flagger course (77.4%). A significant number (87%) earned $50,000 a year or less.

Qualitative Analysis

The researchers for this study were trained on observational techniques prior to the commencement of the study. Thus, each researcher understood both the research project and the treatment they would be observing. This allowed for stronger creditability of the findings. There were always two or more observers for each experimental class, which allowed for more detailed observations of the class. There were eight experimental classes with a combined total of 24 observers. The camera that recorded the experimental class could scan the classroom for better viewing of the adult learners.

The experimental class was videotaped in order to provide the researchers with the opportunity to observe body language during the treatment and not intrude on the actual study. There was a room located in the training site that allowed researchers to remotely view the experimental class in real time, eliminating what could have been perceived by the adult learners as an intrusive presence in the classroom. Viewing the experimental class in real time enabled the researchers to take copious notes on the body language of each adult learner from the minute they stepped into the class and saw the computers until they left the class at the conclusion of the training session. The researchers were careful to note whether any of the adult learners had any type of smart phone with them.

The researchers noted that various adult learners were apprehensive as they stepped into the training room and found themselves faced with rows of computers, as evidenced by the visible stiffening of their bodies and markedly slowness to their steps. The observers noted that the adult learners spoke among themselves about the computers and what kind of training awaited them. As expected, the first adult learners to arrive chose seats in the back of the classroom, and the later arrivals were forced into the front of the class. The observers also noted that the adult learners seemed surprised to see a game controller.

There were several research assistants in the classroom to help the adult learners log on to the computers with their pre-assigned logon id and password. One of the senior researchers explained to the adult learners that the game controller's operation was very similar to that of a joystick in the heavy equipment that they may operate on the job, such as a "trackhoe." That bit of advice seemed to help many of the adult learners with the operation of their game controller. Many of the adult learners expressed concerns that they had never worked on a computer before and were quite concerned.

Once each adult learner was logged on and the treatment began, the observers could see that some adult learners struggled with their game controllers as they completed the initial simulation levels (events). Individuals that appeared to read the on-screen instructions slowly also seemed to take the most time to complete events. Their uncertainty of the game controller and their slowness to complete events were noted. In a few cases, adult learners that struggled in the class were occasionally assisted by their fellow adult learners who completed the event for them. The observers were able to note this external adult learner assistance, and those instances will be included in both quantitative and qualitative future analyses to ascertain if there was any impact on the results.

Age was not a variable that could be used to categorize the adult learners on their behavior in the treatment class. Some individuals that were older completed the events more quickly than younger adult learners. Race was also not a factor during observations. There were limited observations on female adult learners due to the relatively small number of women in the class.

As the adult learners gained experience by completing events, the observers reported a notable change in body language: adult learners visibly leaned forward in their chairs and competed with their neighbor as to how quickly they could complete an event. Adult learners seemed to become more animated as the events continued.

It was interesting to note that even though many of the adult learners were initially very apprehensive about participating in computer based training, almost 95% of the adult learners were found to have some type of smart phone. During the actual training, many of the adult learners were observed using their smart phones in various fashions: scanning email, sending text messages, and reviewing websites.

At the completion of the training, another call for interview volunteers was mentioned and generally a minimum of four individuals volunteered.

Interviews

Doctoral and master's degree candidates, who completed various courses in research methods, including qualitative methods such as how to compose good follow-on probing questions, conducted the interviews. Interviewers consisted of various races and nationalities. The interviewers took notes and audio-taped the interviews for later transcription. All the interviewers used carefully designed initial questions to all adult learners interviewed. Interviews were conducted with a representative cross-section of the experimental sample, to include race, age, socio-economic status, and educational level. The initial review of the transcripts (which formed the basis of this study) clearly revealed the richness of the responses.

The interviews took place in a quiet room, and the adult learners gave permission for the interviews to be taped. Questions asked ranged from why they chose a particular avatar to how realistic this training appeared to them. Every adult learner interviewed stated that this was a new and engaging way to have training. Approximately 40% of the adult learners had never used a computer before but almost 80% had used a game controller in some fashion prior to this training.

Qualitative Findings

Consistent themes emerged from the interviews:

- Safety,
- Being more engaged,
- Increase the interactions within each event, and
- Lack of details on the trucks.

The safety issue was consistent in all of the interviews; every adult learner felt they walked away with an understanding about the need to increase their safety in their workplace. They felt they needed to be more careful on curves and making sure they are watching traffic closer, especially since more people are texting while driving.

This was a pilot study and, though the simulation scenes were realistic, they were limited in road conditions and complexity of roadway (rural two-lane road and only during the daytime). Most of the adult learners wanted to increase the complexity, such as being on a four-lane highway with construction going on in one lane and the traffic having to be diverted into another lane.

Adult learners felt much more engaged in their learning than the traditional class that consists of a PowerPoint presentation. These adult learners had participated many times in the traditional flagger course and felt that it was boring and a waste of their time. They really enjoyed being an active adult learner and felt they learned more, as well. Many of the adult learners noted the lack of details on the trucks – such as lack of rotating lights, no one actually in the cars, and a lack of diversity of vehicle type.

Quantitative Demographic Analysis

In order to ensure data quality, an exploratory and descriptive analysis was conducted to check for coding errors, outliers, missing data, data consistency, distribution of the data, and to extract important variables. The levels of measurements utilized were also verified to ensure the correct measurement was constructed. A select number of cases were chosen, cases 1 – 50 and 250 – 305, during this exploratory analysis and compared to the Excel file containing the non-manipulated data. The minimum and maximum scores/values were determined in each field and compared against the possible range of values to ensure the data correctly reflected the findings.

An independent samples t-test was used to examine the pretest and posttest scores between the control and treatment group to ascertain if there was a statistical difference between the groups prior to and post treatment. An analysis of covariance (ANCOVA) was utilized to further ensure equivalence between the control and experimental groups so the researcher could confirm there were no preexisting differences between the groups despite the randomization. The pretest was the covariate in the ANCOVA. In both the independent samples t-test and ANCOVA, the significance level was set at .05.

Lastly, correlation and multiple regression were utilized in this data analysis procedure. According to Hinkle, Wiersma, and Jurs (2002), multiple regression is a statistical technique that involves predicting criterion variables (posttest score) by examining the relationships between the various predictor variables (demographic variables). The demographic variables of race, educational level, gender, and previous flagging course were recoded into dummy variables prior to analysis. The possible correlations range from +1 to –1. A zero correlation indicates that there is no relationship between the variables. A correlation of –1 indicates a perfect negative correlation, meaning that as one variable goes up, the other goes down. A correlation of +1 indicates a perfect positive correlation, meaning that both variables move in the same direction together (Hinkle et al., 2002). Multiple regression can be defined as an extension of simple linear regression involving more than one independent variable (Hinkle et al., 2002). This technique was used to predict the value of a single dependent variable from a weighted, linear combination of independent variables. Consider multiple regression as a means of seeking the linear combination of independent variables that maximally correlate with the dependent variable (Hinkle et. al, 2002).

Objective One

Demographic data for the combined treatment and control groups (n = 305) indicated that of those responding, the majority of the sample was male (88.3%). The largest ethnic group category was African-American (64.3%), the second largest category was White/Non-Hispanic (33.4%), while there were two respondents in the Other category, and one each in the American Indian/Alaskan and Asian categories. It is interesting to note that 76.0% of the overall sample had a high school degree, GED, or less, and that the largest group of individuals was between the ages of 46 to 64 years (46.6%) of age and had never attended a flagger course (77.4%). In regard to years working as an adult (18 years or older), the data showed that 27.0% had been working between 26 and 35 years, which was the largest group. As far as the number of years worked in highway or maintenance construction, 74.4% had worked 15 years or less, which denotes the largest group in the data. A significant number (87.0%) earned $50,000 a year or less. The sample size in the IVLE group was 165 (54.0%) whereas the control group had a sample size of 140 individuals (45.0%).

Objective Two

Pretest mean score for the control group was 78.19, with standard deviation of 14.00. Pretest mean score for the experimental group was 76.10, with a standard deviation of 15.08. A t-test was utilized to examine the pretest scores between the control and treatment group to ascertain if there was a statistical difference between the groups prior to treatment. The t-test was not statistically significant ($t=1.23$, $p=.22$). In practical terms, the computed value of "t" indicated that the groups could be treated as equivalent. Posttest mean score for control was 89.23, standard deviation of 12.76. Posttest mean score for experimental group was 85.03, standard deviation 14.97. The posttest analysis indicated statistically significant differences between the treatment and control groups ($t = -2.59$, $p=.01$). The pretest score was used as covariate to examine the posttest scores. An ANCOVA was utilized to further examine this data to ensure the finding was true and that preexisting differences could not account for this finding. There was a statistically significant interaction between the fixed factor and the posttest score indicating that the slopes were not parallel, and thus, the pretest scores could not be used as a covariate ($F1, 294) = 6.14$, $p= .01$. Due to this finding, the forthcoming data results and analysis will focus on the treatment group only.

Objective Three

Analysis of frequency distribution for categories of the variable "Age" resulted in the following four categories:

- Category One: 18 – 29
- Category Two: 30 – 45
- Category Three: 46 – 64
- Category Four: 65 and greater

Age Category One contained a sample of n=24, with the posttest mean score of 91.88 and a standard deviation of 12.67. Age Category Two contained a sample of n=51, with a posttest mean score of 84.90 and a standard deviation of 11.98. Age Category Three, which contained the largest sample (n=73), had a posttest mean score of 83.84 with a standard deviation of 16.04. Age Category Four contained a sample of n=4, with a posttest mean score of 87.50 and a standard deviation of 18.48. The Levene's statistic was not statistically significant. Using the Analysis of Variance (ANOVA) technique to analyze the data, results indicated no significant differences between the mean posttest scores by age groups at the .05 two-tailed level ($F=1.965$, $p=.122$).

In regard to analysis of the demographic variable "Gender," males comprised the largest group of the sample with n=136, while women comprised a sample of n=20. The mean score on the posttest for males was 84.96, with a standard deviation of 15.06. For females, the mean score on the posttest was 87.25, with a standard deviation of 12.29. Using the independent samples t-test technique to analyze the data, results provided no significant differences between the mean posttest scores for gender at the .05 two-tailed level, with $p=.518$.

Due to the small numbers of individuals in other ethnic groups (n=4), they were placed into the category of African American for data analysis purposes. As indicated previously, the largest ethnic group, denoted as "Race" in the demographic survey, within the sample was African American (n=103), while the White/Non-Hispanic groups comprised a sample of n=52. The mean score on the posttest for African Americans was 82.67, with a standard deviation 15.46. The White/Non-Hispanic group had a higher mean posttest score of 90.19, with a standard deviation of 11.83. Using the independent samples t-test to analyze this portion of the sample, a significant difference between the posttest scores of African Americans and White/Non-Hispanic groups ($t= -3.35$, $p=.001$).

All participants were compared on the variable education. Education was captured in three categories:

- Category One: Some High School or Graduated High School or GED
- Category Two: Technical Degree or Associates Degree
- Category Three: Bachelor's Degree, Master's Degree, or Other

Education Category One contained the largest sample size ($n=115$), with a posttest mean score of 84.09 and a standard deviation of 15.44. Education Category Two contained the next largest sample ($n=13$), with a posttest mean score of 91.54 and a standard deviation of 10.28. Lastly, Education Category Three contained the smallest sample ($n=12$), with a posttest mean score of 91.25 and a standard deviation of 12.27. The Levene's Test of Homogeneity of Variance was not significant. Using the ANOVA technique to analyze this data, findings indicated that the F test was not significant, $F=2.50$, $p<.086$.

For the demographic factor "Socioeconomic Status," analysis of frequency distribution provided three categories of socioeconomic status:

- Category One: $0 – $24,999
- Category Two: $25,000 – $49,999
- Category Three: $50,000 – Greater

Socioeconomic status Category One contained a sample of $n=51$, with a mean posttest score of 87.45 and a standard deviation of 13.05. Category Two contained the largest sample ($n=72$) which had a mean posttest score of 84.52 and a standard deviation of 15.18. The third socioeconomic status category ($n=15$) had a mean posttest score of 91.00 and a standard deviation of 7.36. Using the ANOVA data analysis technique, there is not a significant difference between the three socioeconomic status categories on posttest score ($F=1.655$, $p=.195$).

Levene's Test of Homogeneity of Variance was noted to be significant with an $F = 4.705$ (4, 133) $p = <.001$ for the categories of the variable "Number of Years Working as an Adult." Welch statistical analysis for number of years working as an adult was utilized after determining unequal variances among categories of the variable, $F = 3.311$ (4, 24.745) $p = <.026$. The categories of the variable are as follows:

- Category One: 0-4 years
- Category Two: 5-15 years
- Category Three: 16-25 years
- Category Four: 26-35 years

- Category Five: 36 plus years

The highest posttest mean score arose in the group of individuals working in category two (n=37), with a posttest score of 90.54 and a standard deviation of 9.19. Category One (n=5) participants had a mean posttest score of 72.00 with a standard deviation of 22.52. Category Three (n=30) participants presented a mean posttest score of 80.83 with a standard deviation of 16.72. Category Four (n=43) participants had a mean posttest score of 86.16 and a standard deviation 11.84. Lastly, Category Five (n=23) participants had a mean posttest score of 91.08 and a standard deviation of 9.16.

The variable "Number of Years Worked in Highway Construction or Maintenance" was determined to be statistically significant in the Levene's Test of Homogeneity of Variance with F = 2.791 (4, 140) p = <.029. Welch statistical analysis for the numbers of years worked in highway construction or maintenance ensued after determining unequal variances among categories of the variable, F = 5.116 (4, 11.697) p = <.013. The categories of this variable are as follow:

- Category One: 0-4 years
- Category Two: 5-15 years
- Category Three: 16-25 years
- Category Four: 26-35 years
- Category Five: 36 plus years

The highest posttest mean score arose in the group of individuals working in Category Four (n=5), with a posttest score of 97.00 and a standard deviation of 4.47. Category One (n=48) participants had a mean posttest score of 87.71 with a standard deviation of 12.76. Category Two (n=57) participants presented a mean posttest score of 87.02 with a standard deviation of 11.83. Category Three (n=32) participants had a mean posttest score of 82.19 and a standard deviation 16.79. Lastly, Category Five (n=3) participants had a mean posttest score of 80.00 and a standard deviation of 20.00.

The final demographic factor analyzed, "Previous Flagger Course," yielded statistically significant results in the independent samples t-test (t=3.097, p=.003). The largest group in the sample (n=118) had not attended a previous flagger course while 36 individuals noted they had attended a previous flagger course. For the individuals who had not taken a previous flagger course, the posttest mean was 83.98 with a standard deviation of 15.65. Individuals who had taken a previous flagger course achieved a higher posttest mean of 90.42 with a standard deviation of 8.97.

Objective Four

In determining the effect size regarding the correlation coefficients, findings were interpreted using Davis' (1971) scale:

- Correlation Coefficient of .70 or higher indicates a very strong association
- Correlation Coefficient of .50-.69 indicates a considerable association
- Correlation Coefficient of .30-.49 indicates a moderate association
- Correlation Coefficient of .10-.29 indicates a low association
- Correlation Coefficient of .01-.09 indicates a negligible association

The correlations were calculated between selected variables and the participants' posttest mean score. A negative low association existed (r= -.224, p= .007) between the participants' education level (some high school or high school/GED) and the participants' posttest mean score. A positive low association existed (r= .113, p= .111) between the participants' education level (technical or associates degree) and the participants' posttest mean score. A positive negligible association existed (r= .029, p= .379) between the participants' gender and posttest score. A negative low association existed (r= -.112, p= .113) between participants' years working as an adult (18 years or older) and posttest score. A negative negligible association existed (r= -.045, p= .312) between the participants' years working in highway maintenance or construction and participants' posttest score. A negative low association existed (r= -.124, p= .089) between participants' previous flagging course attendance and the posttest mean score.

Objective Five

The data were checked for normality, linearity, outliers, and homoscedasticity prior to fitting the regression model. Descriptive statistics are presented in Table 1.

Table 1
Descriptive Statistics

	Mean	Std. Deviation	N
Posttest score	87.9412	11.22595	119
Some high school and high school or GED	.7983	.40295	119
Technical or Associates Degree	.1092	.31326	119
Sex	1.13	.343	119
Age	42.23	12.242	119
Yrs. Wk. Adult	22.66	12.232	119
Yrs. Wk. Hwy/Mt. Constr.	9.433	8.0720	119
Pr. Flagging Crs.	1.75	.436	119

In running the multiple regression using the Stepwise model, the results indicated one variable that entered into the regression model, shown in Table 2:

- Education (Some High School and High School or GED)

Table 2
Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Some high school and high school or GED		Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: posttest score

In addition, Table 3 indicates the multiple regression model summary for the one predicted model. The linear regression model was fit to the data and the results are presented in Table 3. Standardized residuals were plotted against predicted values and showed no significant departures from homoscedasticity. Furthermore, the residuals were normally distributed. The Pearson correlation was computed across the variables of:

- Education
- Gender
- Age
- Years Working in Construction/Highway Maintenance
- Whether or Not Participants Had Previously Taken a Flagging Procedures Course

In Model 1, the R^2 value predicts a 5.0 percent change in the criterion variable from the predictor variables. The Adjusted R^2 value provides how well the model generalizes, and the difference between the R^2 value and the Adjusted R^2 value is 0.008.

Table 3
Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.224[a]	.050	.042	10.98809	.050	6.164	1	117	.014	1.805

a. Predictors: (Constant), Some high school and high school or GED
b. Dependent Variable: posttest score

Table 4 indicates that for each predicted model there is a statistically significant F, F=6.164 p=.014. The data in Table 4 improves our ability to predict the criterion variable based upon the predictor variables that entered as significant into the regression models above.

Table 4
ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	744.229	1	744.229	6.164	.014[a]
	Residual	14126.360	117	120.738		
	Total	14870.588	118			

a. Predictors: (Constant), Some high school and high school or GED

Table 4
ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	744.229	1	744.229	6.164	.014[a]
	Residual	14126.360	117	120.738		
	Total	14870.588	118			

a. Predictors: (Constant), Some high school and high school or GED

b. Dependent Variable: posttest score

The data in Table 5 indicates model was statistically significant at the .05 level. The B values, the slope, provide information about the relationship between the criterion variable (posttest score) and the predictor variables that were identified as significant in the regression. The relationship between education level and posttest score is negative. These values for the slope tell how Y will increase or decrease with each one-unit change in X. The significance values also indicate that these values are making a significant contribution to the predicted models. The standardized B values indicate the number of standard deviations that the criterion variable will change as a result of one standard deviation change in the predictor variable(s).

Table 5
Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	LB[b]	UB[c]	Zero-order	Partial	Part	Tol[d]	VIF
1 (Constant)	92.917	2.243		41.426	.000	88.475	97.359					
Some high school and high school or GED	-6.232	2.510	-.224	-2.483	.014	-11.204	-1.261	-.224	-.224	-.224	1.00	1.00

a. Dependent Variable: posttest score
b. LB = Lower Bound
c. UB = Upper Bound
d. Tolerance

Telemetry Methodology

The Louisiana Department of Transportation and Development sponsored a quasi-experimental research study regarding the use of IVLE technology during the "Basic Flagging Procedures" course. Through randomization procedures, participants were assigned to either the control or experimental group. Over the course of two months, seven control (n=140) and eight experimental (n=165) classes took place. All classes were delivered by the same instructor, which allowed for the instruction to remain consistent. Participants within the control group received traditional classroom instruction which did not involve the use of computers or virtual environments. The experimental groups' training was also primarily focused on the use of IVLE technology as it related to instructional concepts; however, learners assigned to the experimental classes also had instructor-led training. For the control group, the assessments used to measure knowledge and learning transfer were an equivalent pretest and posttest. While these same measures were utilized within the experimental group, additional information regarding how they performed within the IVLE was also collected through a database that tracked 1/10th of each second of movement within the IVLE and answer choices.

During the experimental group classes, participants first received a tutorial regarding operation of the gaming controller, which was the device used during the class to manipulate avatar movement, see Figure 3. The controllers used for IVLE training were standard gaming controllers commonly used in other gaming system technology (e.g. Playstation ®). Learners also received instruction on how to orient themselves within the virtual environment using controller joysticks to direct both the avatar's body and head orientation within the IVLE. The game controllers were also equipped with buttons used for selecting an item or positioning the participants' avatar within the virtual environment. As defined by Bailenson, Blascovich, Beall, and Noveck (2006), an avatar is a representation of a person in a virtual environment. The avatar in the IVLE allowed the participants to execute the procedural tasks that are utilized in a highway construction or maintenance work zone. Additionally, the environment provided within the IVLE consisted of well defined, sharp images that were easy for participants to view and manipulate; see Figures 4, 5, and 6. After the brief introduction to the IVLE, each participant was asked to select an avatar of their choice to represent themselves within the virtual training environment. There were three male and three female avatars from which each participant could choose. Participants were encouraged to select an avatar (see Figure 2) with whom they identified in order to heighten their connection with the avatar and subsequent training/learning transfer within the IVLE.

Figure 2
Depiction female and male avatar in the IVLE

Figure 3
Game controller used by participants in the IVLE

Within each experimental group, class participants received traditional, face-to-face lecture from the instructor before watching a simulated representation of an avatar performing a certain task or set of tasks within the IVLE. After viewing these scenes, the participants were asked to use the controllers and avatars to perform the same highway safety procedures. Activities within the IVLE training course ranged from selecting the correct attire for a highway construction or maintenance flagger to positioning the avatar flagger at the correct location along various work zone configurations.

The IVLE was set up to have various training scenes that required participants to complete a task, such as placing their avatar in the correct location for properly directing traffic through a highway construction or maintenance zone. The participants were informed of what task to complete, at which point they would begin manipulating their controllers and moving their avatar to the correct position. In order to ascertain if the participants placed their avatar in the correct location, the architects of the IVLE, under direction of the researcher, had developed a predetermined mathematical grid, which represented the correct placement of the avatar for each task. In the repeated levels, the mathematical grid was narrower, which required more precision from the participants regarding placement of the respective flagger(s). In the context of this research, a level is defined as the overarching scene in which the participants were required to perform specific tasks. The levels are explained below:

- Level 28: Served as a pretest measurement with the task requiring the participants to position a single flagger at the correct location while demonstrating the correct traffic signals with their arms.

- Level 50: Served as the posttest for Level 28 requiring the participants to complete the same tasks.
- Level 34: Served as a pretest measurement with the task requiring participants to place a single flagger in a short duration and low speed work zone.
- Level 51: Served as the posttest measurement for Level 34 requiring the participants to complete the same task.
- Level 35: Served as a pretest measurement with the task requiring participants to place three flaggers in the correct locations in a sight-obstructed work zone.
- Level 52: Served as the posttest measurement for Level 35 requiring participants to complete the same tasks.
- Level 36: Served as a pretest measurement that required participants to place two flaggers in a long duration and high-speed work zone.
- Level 53: Served as a posttest measurement for Level 36 which required participants to complete the same tasks.

Each participant would move their avatar to the place they perceived to represent the correct placement for their avatar; they would then select the denoted button to determine if they were in the correct location or not. After pushing the selection button on the game controller, a comment statement would appear that informed the participant if they were in the correct spot or not.

Participants could move in any direction throughout the IVLE before using their controller to denote that they were choosing a spot within the environment as their desired position. Each experimental group participant completed the same levels and tasks within each level; however, activity within the IVLE was done at separate computer terminals and independently from other group members. All movement within the IVLE was monitored along with each position selection. When a participant made an incorrect position selection, they were notified of the incorrect selection and directed to continue placing the avatar within the simulated environment until the correct location or action was chosen. Once a correct selection was made, the participants would then finish that activity or scene and advance to a blank screen until their fellow classmates completed that scene.

Figure 4
Flagger in the IVLE displaying the appropriate stop position at the beginning of the work zone cone taper

Figure 5
Third person point of view of a work zone with two flaggers

Figure 6
Flagger in the curve of a work zone

Telemetry Data Collection

Running in the background of each participant computer terminal was a sophisticated data collecting and tracking system that assessed the avatar flaggers' movements every 1/10th of a second. This software ran unobtrusively, retrieving raw data regarding participant movement within each of the interactive IVLE scenes. In order for the instructor to track participants' progress in each interactive IVLE scene, a dashboard ran on his computer monitor providing him with feedback regarding when each participant completed each level in order to aid him in gauging the appropriate amount of time spent in each level. From the time an interactive portion of the training began until the participants each passed that level, the tracking program measured both the time and precision of the participants' movements within the IVLE. While time was measured, the researchers were also highly concerned with the precision of avatar flagger placement within the IVLE. In terms of this research, precision is defined as the degree of refinement with which an operation is performed or a measurement stated (Merriam-Webster, 2008). If a participant moved directly from Point A to Point B, his or her movement within the IVLE was considered highly accurate. If a participant moved from Point A down the road toward Point C only to turn and move back toward, eventually reaching, Point B, then his or her movement within the IVLE was considered less accurate. Tichon (2007), stated "Event based training in VR allows novices to be trained to recognize all relevant cues and thereby increases the likelihood of their being able to also head off a problem before it develops. Presenting real-world problems in VR provides a means whereby trainees can gain experience coping with complex operations" (p. 287).

Additionally, telemetry information was used not only to track right and wrong answers, but also to assess how close to the desired target within the IVLE all of the "correct" responses were. While correct answers were all accepted and passed to the next level, some answers were considered more correct or closer to desired location than others. "Predetermining the link between final performance measures and training events in the construction phase of VTEs (virtual training environments) results in performance assessment which is constant across trainees and therefore supports cross comparison of results" (Tichons, 2007, p. 287).

Demographic data were collected through a researcher-created instrument and administered at the start of the class to each participant for completion. All demographic surveys were coded with participant student numbers to ensure confidentiality.

Telemetry Results

Although there were a multitude of levels within the IVLE, the levels analyzed consisted of those levels which were repeated by each participant. The repeated levels were those levels that contained interactive scenarios through which the participants would evaluate the work zone situation and then place the flagger(s) in the correct location based on the environmental scenario.

Objective One

Demographic data for the combined experimental group (n = 165) indicated that of those responding, the majority of the sample was male (86.1%). The largest ethnic group category was African-American (64.8%); the second largest category was White/Non-Hispanic (31.5%), while there was one respondent each in the Other and American Indian/Alaskan categories. It is interesting to note that 76.8% of the overall sample had a high school diploma, GED, or less, and that the largest group of individuals was between the ages of 46 to 64 years (50.0%) of age and had never attended a flagger course (76.3%). In regards to years working as an adult (18 years or older), the data showed that 31.3% had been working between 26 and 35 years, which was the largest group. Regarding the number of years worked in highway or maintenance construction, 72.0% had worked 15 years or less, which contains the largest group in the data. A significant number of participants (88.8%) earned $50,000 a year or less.

Objective Two

Level 28 was repeated as Level 50 and required the participants to place a single flagger in the appropriate location in the work zone and then select the appropriate hand signal for the oncoming traffic. Level 34 was repeated as Level 51 and required participants to place a single flagger in a short duration and low-speed work zone. Level 35 was repeated as Level 52 and prompted the participants to place multiple flaggers in the correct locations within the work zone. The scenario(s) did not indicate to the participants what the correct number of flaggers was to be, but they were prompted to place multiple flaggers and were asked the number of flaggers they believed were necessary in the scenario. Levels 35 and 52 required the participants to place three flaggers in the appropriate location within a site-obstructed work zone. The last comparison levels were Level 36 which was compared to Level 53. Levels 36 and 53 required the participants to place two flaggers in the long duration and high-speed work zone, with the same prompts for placements as in Levels 35 and 52.

A distance integral was calculated for each participant on Levels 28/50, 34/51, 35/52, and 36/53. This distance integral tracked the placement of each participants' avatar as they moved to their desired target for correct flagger placement. Due to extreme skewness in the data and in order to reduce the impact of outliers in the data, a nonlinear transformation using a base 10 logarithm was utilized (Warner, 2008). Warren (2008) stated, "This type of data transformation can bring outlier values at the high end of a distribution closer to the mean" (p. 155). After the nonlinear transformation was utilized, a paired samples t-test was implemented for data analysis.

The distance integral mean for Level 28 was 2516.51, with standard deviation of 3487.33. The distance integral mean for Level 50 was 2643.70, with a standard deviation of 4769.73. The paired samples correlation for Levels 28 and 50 were highly correlated ($r=.476$, $p= < .001$); however, the paired samples t-test for Levels 28 and 50 was not statistically significant ($t= -.350$, $p=.727$). The distance integral mean for Level 34 was 1433.36, with standard deviation of 1944.63. The distance integral mean for Level 51 was 1559.95, with a standard deviation of 3658.04. The paired samples correlation for Levels 34 and 51 were highly correlated ($r=.215$, $p=.010$); however, the paired samples t-test for Levels 34 and 51 was not statistically significant ($t= -.403$, $p=.688$). The distance integral mean for Level 35 was 5074.17, with standard deviation of 4443.47. The distance integral mean for Level 52 was 3478.45, with a standard deviation of 4912.24. The paired samples correlation for Levels 35 and 52 were highly correlated ($r=.334$, $p= <.001$); additionally, the paired samples t-test for Levels 35 and 52 was statistically significant ($t= 3.217$, $p=.002$). Lastly, the distance integral mean for Level 36 was 3142.33, with standard deviation of 2716.69. The distance integral mean for Level 53 was 2327.23, with a standard deviation of 2400.39. The paired samples correlation for Levels 36 and 53 were highly correlated ($r=.277$, $p=.004$); also, the paired samples t-test for Levels 36 and 53 was statistically significant ($t=2.744$, $p=.007$).

Telemetry Visualization

Additional research on the IVLE data set was conducted through visualization and the filtering and calculation of derived data to support statistical analyses and data mining efforts. A significant quantity of data was collected during the LTRC/TTEC/LSU experiment described previously. The prototype was instrumented to capture telemetry data, i.e., positions and orientations of the student's avatar, at approximately 10 samples per second, resulting in a data set that consisted of over 40,000 files. The data architecture required to capture and manage the data was elegantly complex and investigators recognized that additional time was required to perform statistically sound analysis of the volume of data and to produce usable imagery. The follow-on work included production of image sets based on the spatial and temporal data, and valid and rigorous statistical analyses of the data.

Specifically, approximately 20,418 intermediate image fragments were generated, analyzed, processed (rendered for optimum resolution and scaling), and manipulated to produce 1661 spatial images representing every student and their data at every virtual learning environment level. These images then were consolidated into 117 web based pages for easier viewing and visual comparison. Samples of the web pages follow:

In this first image (Figure 7, below), the spatial movement of the avatar for a student is displayed. The problem posed to the student was to place the lead flagger avatar in the correct position. The student attempts to move the avatar to the correct position (depicted by the red line) and when they think they are in the correct spot (the target), they press a specific button on the controller. Incorrect placements are indicated by the blue dot, the correct placement is the white dot within the target, which is the green rectangle (not visible to the student in the virtual world).

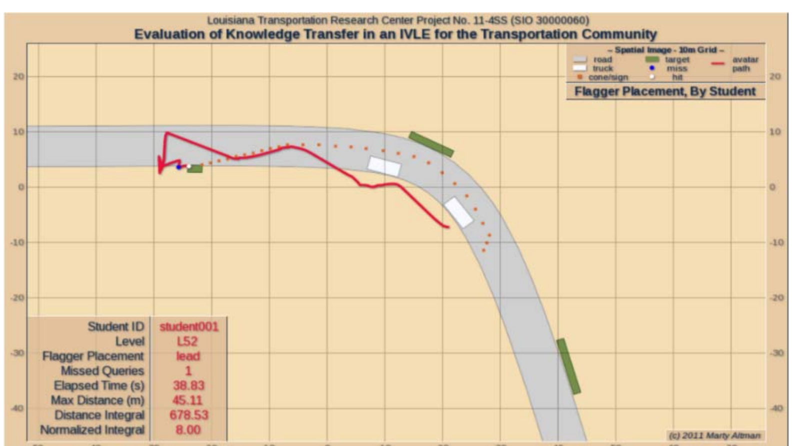

Figure 7

Spatial data display for one flagger problem

However, the researchers realized that a representation of spatial data alone fails to accurately indicate if true learning transfer had occurred. This is because a student could theoretically continuously move and guess until the avatar was properly placed, but there would be no indication of how long it took to achieve success. By including a depiction of the temporal data as well, the researchers gained a better understanding of the level of comprehension of the student.

In the chart below (Figure 8), both spatial and temporal data are depicted. Note that there is a period of time from the start of the exercise until avatar movement begins (depicted by the horizontal portion of the red line). This 9 second delay was the result of the lag time between when the instructor opened the exercise for the students and when the student began to move the avatar. Movement of the avatar is depicted by the curvilinear portion of the red line and relative distance to the target is depicted by the red line moving closer to, or further away from the x axis.

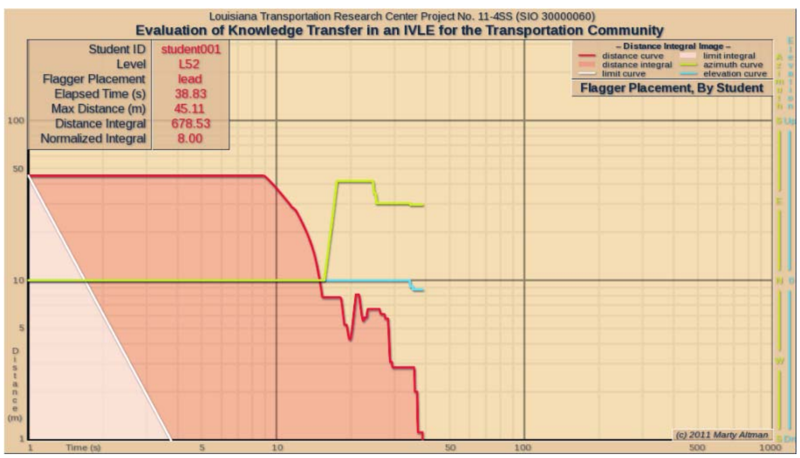

Figure 8

Spatial and Temporal data display for one flagger problem

Through the advanced analysis of this data, the initial results of the first research project were confirmed as it relates to the success of this type of learning technology with the marginalized adult learner. Through these efforts, learners who may have previously been unengaged in the classroom are provided with the opportunity to fully immerse themselves in the learning environment.

This research demonstrates that an IVLE can be successful in delivering training to a marginalized population. Computer skills are not necessary for successful training in an IVLE environment as game controllers can be used and these controllers mimic the systems used to operate heavy equipment, which was utilized in daily work tasks within the accessible population. Due to the fact that each participant had an individual computer for this training, they were able to fully participate in the training without fear of judgment by others participants in the training while the application of their learning could be captured. In normal training events, only one or two individuals generally opts to participate in table top work zone scenarios while other participants watch. Thus, the trainer is unable to measure whether or not each individual can apply his or her knowledge. This training allowed the participants to practice placement of flaggers in the construction or maintenance work zone locations without any the risks they would normally encounter in the real world due to the traveling public, dangerous weather conditions, obstructed lines of sight, or machinery.

CONCLUSIONS

Although research into technology, specifically IVLEs, has occurred is various disciplines, this research focused on the marginalized population which, until this research occurred, had been excluded from empirical research. The current body of literature provided a theoretical foundation in reference to critical benefits that can be garnered through the use of IVLE technology in the classroom. The purpose of this research was to answer the question: Is an Immersive Virtual Learning Environment (IVLE) a more effective method for delivering the procedural content in the "Basic Flagging Procedures" course to aid in the imprinting of the concepts presented regarding maintenance and construction work zones? This question has been addressed through various data analysis techniques, both through quantitative and qualitative methods.

Conclusion 1

Based on the findings of this study, the researcher concluded that participants who took part in the experimental group displayed progressive improvement in the application of the flagging procedures while in the IVLE, as denoted in the IVLE telemetry data. Learners in the marginalized population can benefit from the experiential learning that occurs while in the IVLE as it fosters the necessary application of principles, rules, and regulations that are associated with flagger duties in construction or maintenance work zones.

Conclusion 2

The researcher also concluded that participants who participated in the experimental class were more engaged in the learning process than they had been in traditional style classes, as denoted in the qualitative interviews. Such engagement in the classroom is critical not only for learning transfer but for application of the principles when returning to the work site (Bangert-Drowns & Pyke, 2001). Blascovich, Loomis, Beall, Swinth, Hoyt, and Bailenson (2002) provided that IVLEs hold the promise to increase the actual presence and could hold the key to obscuring the distinction between face-to-face and "electronically mediated social interaction" (p. 111). Persky, Kaphingst, McCall, Lachance, Beall, and Blascovich (2009) defined presence as, "[P]resence is understood as perceiving as reality the VE as opposed to the physical environment encompassing the VE" (p.263). Arguably, Kapp and O'Driscoll (2010), Witmer and Singer (1998), and Blacscovich et al. (2002) each asserted that presence is a critical element for a student in order for engagement in the IVLE to not only occur but to effectively occur. The findings of the qualitative portion of this research not only supported the assertions of these researchers but confirmed that those individuals within the marginalized population are as equally as engaged through the use of technology as other learning populations.

Conclusion 3

From the findings in this study, the researcher concluded that despite the lack of literature relating to research of the marginalized population within an IVLE, this population can be and was successful through this type of educational intervention as demonstrated by the results of the distance integrals in the telemetry data. One can make various assumptions as to why this population has yet to be studied in regards to IVLE technology in the classroom; however, those assumptions are not nearly as critical as the fact that the marginalized population can succeed and learn through this type of instructional technology. Components of a successful program for the marginalized population include:

- Ensure that the IVLE contains a variety of engaging experiential learning activities that foster the encoding of the principles for the participants (Kolb, 1984).
- Encourage feedback regarding the realism of the IVLE in relation to the actual work environment (Kapp & O'Driscoll, 2010).
- Foster a healthy desire for problem solving and decision making for the learners since mistakes within the IVLE can aid in the ultimate understanding of the critical principles (Ellaway, 2005).
- Create an inclusive learning environment that removes any potential boundaries of apprehension for the learners as many individuals are intimidated by the classroom in general, which could be increased through the use of technology (Kapp & O'Driscoll, 2010).

RECOMMENDATIONS

As with any research, there are lessons gained by taking part in the various stages of conducting an experiment of any type. Some of the critical recommendations from this research, as it relates to a marginalized population, are as follows:

- Ensure the content for the chosen course is extremely specific. In order to transform a traditional style course into an IVLE, minutia is paramount for IVLE architects. Such levels of specificity also aid instructional designers in integrating and IVLE into a traditional classroom environment.
- Assessment instruments should be designed to address the information delivered in the course content and written in a manner which is utilized in audience appropriate language.
- Utilize a team of subject matter experts to aid in the refinement of the IVLE.
- Institute a minimum of five pilot testing sessions for the IVLE with the panel of subject matter experts, instructional designers, IVLE architects, and a selection of individuals that are representative of the accessible population.
- Document all processes throughout the progression of the project to allow for information to be readily accessible at any point.
- Gain buy-in from all stakeholders that will be impacted by the implementation of an IVLE in an educational environment.
- Develop a community of practice to engage in scholarly discussions regarding research progress, as well as aiding in staying abreast of the newly published research in the area of study.

Future Research

The further development of research into utilizing IVLE instructional technology with the marginalized population is critical to the refinement of future programs with this population. Areas of future research include, but are not limited to, the following:

- Determine the ideal level of immersion while utilizing IVLE technology in the classroom with the marginalized population. Does an ideal level of immersion exist within the IVLE that will reduce participants' cognitive load while increasing learning transfer and allowing the learners to encode the necessary cues and clues for application in the work environment?
- Compare participant success in the IVLE based upon level of immersion. Does participant success in the IVLE depend upon the level of immersion?

- Include the pre and posttests in the IVLE and eliminate the traditional paper tests, and compare the results of those individuals that took the IVLE tests to those that took the traditional paper tests. Are those individuals that take the pre and posttests in the IVLE more successful than those individuals that take the traditional paper tests?
- Expand research to include surrounding states that have varying demographics and compare the results of those individuals' success rate in the IVLE based one select demographic characteristics. Does success in the IVLE differ in surrounding states based upon the varying demographics?

While IVLE instructional technology is widely used and highly accepted in the fields of K-12, the United States Military, the medical community, and collegiate environments, this type of instructional technology has not been utilized for instruction with the marginalized population. This type of technology is cost feasible and positively impacts the engagement of learners, as well as positively impacting the knowledge transfer to real-life scenarios. IVLE technology is as successful as face-to-face instruction with the marginalized population and quite possibly will aid in the long-transfer of knowledge for participants versus short-transfer of knowledge.

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