Assessing 3D Virtual World Disaster Training Through Adult Learning Theory

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Abstract

As role-play, virtual reality, and simulated environments gain popularity through virtual worlds such as Second Life, the importance of identifying best practices for education and emergency management training becomes necessary. Using a formal needs assessment approach, we examined the extent to which 3D virtual tornado simulation trainings follow the principles of adult learning theory employed by the Federal Emergency Management Agency's (FEMA) National Training and Education Division. Through a three-fold methodology of observation, interviews, and reflection on action, 3D virtual world tornado trainings were analyzed for congruence to adult learning theory. The relationship between simulation and reality through 3D virtual world experience in a "safe" place were examined and the qualitative results confirm that 3D virtual worlds seem to align with some classic tenors of adult learning theory.

Keywords: *Virtual worlds, Disaster simulation, Role-play, Adult learning theory, Constructivism*

1. Introduction

In October 2006, more than a year after Hurricane Katrina landed, President George W. Bush signed into law the Post-Katrina Emergency Management Reform Act (PKEMRA) modifying the organizational structure, authorities, and responsibilities of the Federal Emergency Management Agency (FEMA Public Law 107-296)[1]. Alongside other mandates, PKEMRA requires national learning exercises take place every two years aimed at testing and evaluating the country's level of national preparedness when severely stressed. These national exercise programs are intended to be realistic re-enactments of large-scale disasters based on calculated risk assessments. Despite continual efforts to improve training scenarios, FEMA reports basic challenges to face-to-face (F2F) training (US Gov, 2007)[2]. Not only is it extremely expensive to engage participants across the country in such exercises, but it is difficult to ensure each exercise meets the individual needs of adult learners (US Gov, 2009; Paton, 2003)[3].

Alternatively, studies on the effectiveness of simulation through role-play for education, scientific advancement, and training increasingly conclude that 3D immersive learning environments provide advantages over face-to-face training. Simulated experiences reduce risks of physical harm to participants and eliminate travel costs while offering challenging risk scenarios [4][5][6]. Jamaludin conducted a study of adult learners who spent eight weeks in a virtual world, role-playing a family facing euthanasia [7]. After five role-play sessions, adult learners reported the virtual experience felt as "real as face to face." A second study suggests that students in 3D learning environments out-perform those in F2F classrooms in medical and health related fields [8]. The study investigated a decade of simulation studies in nursing pedagogy and concluded that the advantages gained by role-playing in a 3D virtual environment was equal to the advantages of role-playing in real-life; hence, both simulated and physical world practice hours are required for student nursing practicums. Oliver and Carr conducted a research study of couples that role-played together in online games, such as World of Warcraft [9]. Five couples were observed and interviewed, using the Communities of Practice model as a theoretical framework to understand the learning processes involved. The researchers found little direct relationship with formal curricula and the ludic skills developed through gaming; however, the social and material skills documented presented evidence of usefulness in integrating game-based learning into education. Similarly, a role-play game at the University of Canterbury engaged participants in a 3D simulation of individual behavioral responses

to rising fuel prices. Role-play elements within the game, Travel Activity Constraint Adaptation Simulation (TACA), were examined for attitudes and travel behaviors of players. The study found that through role-play the virtual reality game participants felt better able to evaluate their own behavioral responses to rising fuel costs and make more informed choices in the future [10].

Although extensive research has identified these as well as other benefits of 3D virtual world trainings, few formal needs assessments have compared 3D virtual world trainings to the classic requirements of adult learning theory. Using a formal needs assessment approach, our study inquires if 3D virtual world tornado trainings can meet the needs of adult learners. Both researchers observed and participated in the simulations. One researcher conducted interviews and the other researcher recorded the simulations through machinima (capturing video with the online virtual world). The goal of the research was to explore 3D virtual world simulations for real world problem solving in an immersive learning environment with adult learners.

This paper begins with an overview of the framework and a brief history of Adult Learning Theory. The structure continues with the purpose and questions of the study followed by the methodology designed to examine outcomes. Three formal needs assessment measures are presented: observation, interviews, and reflection on action. Limitations of the study and future research needed are provided before the conclusion.

2. Framework of Adult Learning Theory

Malcolm Knowles [11] identified six principles of Androgogy in adult learning theory: (1) a need to know, (2) prior-experience, (3) self-direction and control of purpose, (4) a readiness to learn what is relevant, (5) problem-centered rather than content–oriented knowledge to master, and (6) self-motivation [12]. He believed that adults learn through collaboration on real world problems that correspond to life situations[13]. His theory of Androgogy is compatible with earlier educational psychologists who also shared a similar constructivist approach: John Dewey and Lev Vygotsky.

As early as 1916, Dewey recommended a problem-solving method for discovery-based learning. Dewey believed learners must become actively engaged in solving problems and that a learner's engagement is motivated by personal interest in real life problems. To engage learners, teachers should serves as guides or facilitators of learning instead of lecturers or directors [14]. Russian behavioral psychologist, Lev Vygotsky, also focused on how best to teach, theorizing that teachers should identify the subject areas in which students can achieve success with guidance. He called these areas the 'zone of proximal development' (ZPD). The ZPD, according to Vygotsky, should be the starting place for all instruction. In order to master information in the ZPD, humans must learn through collaboration with each other [15].

Ron and Susan Zemke added to the research in adult theory by building on Knowles' Androgogy, Dewey's belief in active engagement, and Vygotsky's ZPD. Zemke (1995) believed there is a "window of opportunity" or special time when adults are motivated to learn. Adult learners are most-often motivated to learn when faced with a real life personal interest or problem; however, Zemke states that an adult learner's motivation may also be influenced by curiosity [16].

3. Purpose and questions of methodology

The study aims to investigate how well 3D virtual worlds disaster trainings meets adult learning theory by conducting a formal needs assessment of five 3D virtual tornado rescue missions. Three of the missions were conducted as "practice sessions" and two were held as live events captured with machinima (video shot inside a computer game or simulated environment). Participants agreed to attend a training session and at least one of the live events. One problem, which is addressed in Section 10, was the various skill level of the volunteer participants and the lack of clear learning goals as the study was designed to observe the learning at any level of experience. The researchers intentionally aimed to observe the learning of the participants at various levels without giving them specific objectives for the purpose of authenticity. We based our definition of adult learning theory from the well-known research of four constructivist learning theorists: Malcolm Knowles, John Dewey, Lev Vvgotsky, and Ron and Susan Zemke. During each of the five 3D virtual tornado rescue

missions, we employed three formal needs assessment methodologies: observation, interviews, and reflections on action [17][18][19] to seek answers to the following questions drawn from the views of four aforementioned adult learning theorists:

1. Question 1 (Q1) To what extent, were participants involved in a problem-based learning situation that encouraged self-direction towards learning?
2. Question2 (Q2) To what extent did learners exhibit prior knowledge, a "readiness to learn" and collaboration skills?
3. Question 3 (Q3) To what extent did participants exhibit signs of personal motivation, interest, and active engagement?

A formal needs assessment, based upon a 3D virtual tornado rescue simulation, took place over the course of two months. Ten individuals, all volunteers responding to recruitment from email and Second Life education group invitations, agreed to participate in a series of five virtual tornado rescue missions sponsored by the Texas Library Association Second Life Community Group and TRP360, a 3D building and emergency exercise company [20]. Librarians interested in the use of virtual worlds for providing high quality resources met with the 3D virtual world builder specializing in rescue operations who organized the distribution of necessary items: vehicles, clothing, accessories and equipment.

Human-computer interaction modalities require specific problem-solving strategies within a simulated mission, some of which are yet unknown as 3D virtual worlds are an emerging innovation. This study presents a balanced look at the learning objectives in a 3D virtual environment from the perspective of adult learners choosing roles in an emergency simulation. At the start of each mission, participants visited a virtual tornado exhibit, built by librarians, to learn more about the background and history of tornados, then travelled to a 3D emergency exercise build to play a pre-defined role in an emergency rescue effort. Assigned roles included: victim, police, emergency medical responder, firefighter, reporter, videographer, task force or hazmat unit. Participants, all volunteers were given the choice of role assignments. Latecomers became victims or people who simply stood by and witnessed the chaos. Throughout each mission, participants were expected to collaborate, communicate, and respond to complications caused by a virtual tornado in real-time. Each participant received a uniform, 3D accessories, and vehicle, appropriate to the role played. Inside each mission's one to two-hour time frame, participants practiced basic first responder movements, which might occur in the aftermath of a tornado with little direction and communications. For purposes of the study, the traditional training pattern of TRP360 virtual training was altered to fit a two-hour virtual tornado training session versus a typical one-week long exercise done in conjunction with a table-top activity. Study participants consented to being observed, videotaped and interviewed.

Figure 1. Examples of avatar roles

3.1. Data Collection Instruments

Three formal needs assessment measures were employed: observation, interviews and reflection on action [17][18]. First, observations took place while participants role-played distinct emergency rescue roles throughout the virtual tornado rescue mission. Second, participants agreed to be interviewed in a one-on-one setting. Finally, we performed a reflection on action. Reflection on action is a formal needs assessment methodology, drawing from experiential learning models

whereby print, video or verbal recordings of training events or learning activities are used as a trigger to recall and identify what was done well and what could have been done better.

4. Formal needs assessment measure 1: OBSERVATION

4.1. Q1 To what extent were participants involved in a problem-based learning situation that encouraged self-direction towards learning?

Over the course of five virtual tornado rescue missions, researchers observed 10 participants engage in specific tasks inherent to the character they played. Victims, for example, were expected to use unique animations to signal for help, vomit blood, or display visible injuries. They walked around a virtual downtown area until the tornado hit. Once the tornado appeared, they could become literally tangled in it, and/or cry for help, and then, display injuries. Those role-playing emergency medical responders, however, had a different set of duties. They were expected to drive an ambulance, identify victims, display empathy for them, place them on stretcher, lift the stretcher onto the back of an ambulance, then, drive the ambulance to a nearby hospital. Over time, it became clear that the less involved a participant was in managing the technology, the more effort individuals focused on realistically role-playing the virtual character. In short, all roles required participants to problem-solve; however, the type of problem-solving differed for each role as each role offered a different set of technical and role-playing challenges. Those who had mastered the technology seemed to focus more on problem-solving the role-playing challenge. They stayed in character more often - realistically trying to mimic the language used in a tornado rescue mission and interact with others appropriately – compared to those absorbed with managing the virtual world technology. Often, participants seemed to self-direct learning especially at the point at which they were given the option of choosing their role and outfitting their avatars accordingly. The questions asked in chat and physical actions of the characters made it clear that all were reading the notecards and reacting in ways appropriate to their chosen role. A firefighter, for example, had to learn how to aim a hose at a fire and release virtual water. In this staging area, she was observed practicing. Similarly, a reporter was observed trying to use a videocamera animation so her avatar would appear to balance a videocamera on her shoulder or hold a microphone in a hand. In every mission, prior to its start, participants were observed directing their own learning. This engagement and self-directed learning seemed to appear with more participants in greater numbers right before the launch of the virtual tornado mission compared to an earlier point in time. In other words, the learners were not only learning to react in an emergency, but were simultaneously learning the tools necessary to simulate that reaction.

Figure 2: Victim writhes in pain in ambulance

4.2. Q2 To what extent did learners exhibit prior knowledge, a "readiness to learn" and collaboration skills?

Throughout tornado missions, participants compared prior experiences or knowledge of roles worked in real-life to the virtual one. For example, one participant questioned which emergency vehicle should appear on the scene first – police, fire truck, or ambulance. Ensuring the virtual protocol authentically captured the order in which each rescue unit should arrive was important to participants who had practiced similar emergency preparedness simulations in real-life. Those who had not experienced this type of emergency exercise expressed an interest in the order and progression of the simulation. They often lingered long after the pre-scheduled event. Their 'readiness to learn' was often visible in questions asked about the event itself and seemingly triggered by the natural anticipation of a virtual performance. In a sense, every participant had a role to play and knew they must react to the tornado appropriately. To react well, they needed and requested information. By the third 3D virtual tornado rescue mission, it became obvious which participants had prior knowledge in virtual world skills or in gaming. For example, one participant, who was new to virtual worlds expressed that it was not difficult to drive the emergency vehicle due to his background in video games while others with little prior knowledge of video games or virtual worlds struggled to use uniforms and gear. In addition, participant willingness to attend virtual simulation practices in the evening hours, across the U.S. in various times zones, also illustrated a readiness to learn the required skills. Their readiness to learn also became apparent in frequent attempts to collaborate with and gain knowledge from others. For example, a reporter needed to interview those at the scene and often stopped participants to engage them in a live interview. At another moment, in one particularly difficult simulation, an emergency rescue worker tried repeatedly to put a victim on top of an ambulance stretcher and into the back of the ambulance. Without breaking character, another participant offered advice on how best to trouble-shoot the stretcher.

4.3. Q3 To what extent did participants exhibit signs of personal motivation, interest, and active engagement?

Signs of personal motivation and interest were visible in varied conversations and text messages among participants. For example, in one tornado rescue mission a heated discussion broke out about which aspects of the virtual world events generated a greater sense of realism. Excitement could be heard in their voices. Once the role-play actually started (during the two live simulations), their dialogue became life-like as each role-play character spoke in real time as if the event was actually taking place. Several individuals expressed curiosity about the future of simulation in education and other fields. Upon conclusion of the project, many expressed a personal interest in attending other similar role-play events.

If user engagement in a virtual world can be measured by "the emotional, cognitive and behavioral connection that exists, at any point in time and possibly over time, between a user and a resource" [21] it is clear the virtual tornado rescue mission demanded a high level of engagement for participants. The majority of users stayed for the length of time required by the mission despite the fact that most missions lasted longer than the estimated time frame. Several commented on both the aesthetic beauty and usefulness of the virtual tornado build and user tools such as fire trucks, ambulances, and police cars. One participant mentioned that the virtual news alert running on a police car's CB radio reminded him of an instance in the real world when he had heard a similar CB alert. This statement provided evidence of realism and the transfer of learning to the real world in a serious situation. At times the participants expressed laughter or frustration during some of the intense moments of preparation as some struggled to manipulate scripted objects, such as stretchers or animations. A determination to succeed and master a difficult skill was witnessed numerous times. For example, one participant (role-playing a victim) found it extremely difficult to enter the ambulance and spent about 30 minutes trying various positions and mouse clicks.

5. Formal needs assessment measure 2: INTERVIEWS

After the virtual tornado exhibit and live simulation took place, the ten participants (Participants 1-10) consented to be interviewed in the virtual world. Some of the participants participated in all of

the sessions, including training, while a few participated only once. The interview questions were generic in nature, seeking to understand participant perceptions of the virtual tornado missions and prior experiences in both the virtual world and real-life. Responses from the interviews were analyzed for correlations to three questions relating to adult learning theory.

5.1. Q1 To what extent, were participants involved in a problem-based learning situation that encouraged self-direction towards learning?

When interviewed, participants described the rescue mission as presenting two problems – the role-play problem and the problem of managing the virtual world environment and the tools within it, such as animations. Participant 2 [22] said, "I think we were learning on two levels. We were learning what a virtual rescue might be like but we were also learning the platform and how to function with the new tools in this environment." Participant 8 [23] also mentioned, "Much of my difficulty was in controlling my avatar. I knew what I should be doing but a lot was happening. I had to type, control the avatar, read, and make my avatar respond." Participant 10 [24] shared some of the questions he asked himself as he role-played a tornado victim. He wondered if his avatar could break a leg or dislocate a shoulder during the tornado training. He expressed concern and hesitation about how best to react to a tornado. "What were the rules?" he said. "Should I crouch down? At one point, I lost track of others in my group; I didn't see them." His statements clearly expressed involvement in how to direct his actions during the problem-based learning situation. Similarly, Participant 5 [25] stated, "I had trouble getting into the ambulance in the second training session. I had trouble with the stretcher because it didn't load into the ambulance. Pushing the stretcher was easy but letting go and having someone climb in was hard." P10 said, "What people don't realize until they take part in this is that the actual event is very tense and stressful. It is similar to real-life. There is a lot going on simultaneously. It makes people aware of the level of chaos in an emergency." P5 commented that some sessions presented more challenges than others. "In one session, the ambulance driver ran over the person playing the police officer." Participants also stated that a choice of roles contributed to a sense of self-direction. For example, Participant 8 explained, "I played the victim. It was easiest because I knew that once I was saved, I didn't have to do anything. "Another individual, Participant 6 [26], who chose the role of a firefighter, remembered thinking, "'What would a firefighter do?' (I asked myself.) …and tried to place myself in the role of a firefighter in the aftermath of a natural disaster."

Figure 3: Firefighter, reporter, and victim during role-play

5.2. Q2 To what extent, did learners exhibit prior knowledge, a "readiness to learn" and collaboration skills?

Participant 1 [27] reported prior knowledge of EMS training and readiness to learn during the interview. He said, "I was thinking about my own real-life EMS training." He recounted a situation he had faced in real-life. "A child stood outside a gate but because we were not allowed to go outside the gate to administer first aid. The child bled to death." He added, "There is real value in what we can do (in virtual practice). You work through many difficult choices." Participant 2 mentioned that

his son was studying to be an Emergency Rescue Worker (ERW) so he was more aware of and sensitive to the difficulties facing ERWs than he might have been otherwise.

As a way of accessing collaboration levels between participants, participants were asked to rate themselves as a beginner, moderately skilled, or advanced user of Second Life. Two participants rated themselves as beginners, two participants as moderately skilled, and six as advanced users of the virtual world. This varying degree of knowledge and skills made it critical for the participants to help each other throughout the simulation. On the topic of collaboration, Participant 1 wrote, "I see some parallels in training in real-life versus training virtual worlds. One of the key things you have to learn in these situations is to develop trust in your co-workers. I may not see them (in the chaos) but hopefully, with practice and with training, there is a level of hope and optimism that they are there doing what they need to do."

Figure 4: Reporter, victim, and police officer

5.3. Q3 To what extent did participants exhibit signs of personal motivation, interest and active engagement?

All of the ten individuals interviewed found the virtual rescue role-play to be interesting and demonstrated personal motivation. Participant 1 said, I was seeing avatars as real people and thinking about how people are trapped by a big event." Participant 2 said, "Virtual worlds offer a sense of presence you don't necessarily get with tools like Elluminate or Blackboard." Participant 3 [28] stated, "A virtual world doesn't hold you back. It's a more creative view of the surrounding areas." Participant 4 (P4) shared, "The first time I drove the fire truck, I was amazed it worked as well as it did. P5 stated, "I tried to be as realistic as possible. I laid down in the ambulance and crouched down on the street (as a hurt victim)."P6 shared, "When I thought there were too many people in one role, I switched roles." Participant 7 [29] stated, "The tornado was pretty cool. Stuff was flying around. Someone got caught inside the tornado and was flying around. That was pretty cool- that the tornado could pick up people."P8 said, "A lot was happening. I had to type, control the avatar, read, and make my avatar respond." Participant 9 [30] said, "I was thinking that it was fun and an interesting (learning) model." P10 stated, "I was impressed with the level of detail in the recreation."

Participants gave numerous examples of engagement in learning. P2 stated, "I ended up being the EMS worker every time. I was thinking of trying to reach those victims as quickly as I could get there in time. I wanted to work the equipment to save the victims. I drove the ambulance." Another P5 stated, "I was a victim. If I had to evaluate my work, I'd say I acted more hurt and more emotional the second time around." One individual, role-playing a firefighter (P6) told the interviewer, "We ran around and put out fires. I did try to help the victims. I ran around calling for help in the role-play...I tried to place myself in the role of a firefighter in the aftermath of a natural disaster." P2

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added, “When we were running the simulation, I felt some pressure to stay in the role. I was the one kneeling by the victim, asking, ‘Ma’am, are you okay? I’m going to help you get into the gurney.”

Figure 5: EMS worker crouches to help victim

Difficulties were also presented during the virtual experience. P8 shared, “I had my computer crash once. Second Life can be buggy. Sometimes the visuals hadn’t delineated 3D graphics.” P2 said, “I think it gives you a taste of what learning can be like when it is active instead of passive.” Similarly, Participant 4 [31] mentioned the difficulties inherent in the fact that the virtual tornado landed on the town differently each time. Fires erupted in different locations. She described a particular mission where the fire hit the fire truck. “I couldn’t get out. I burned up in the fire truck. I froze. I couldn’t get out in time. Participant 2 said you get virtual butterflies.”

Figure 6: EMS worker struggles to drive the ambulance

6. Formal needs assessment measure 3: REFLECTION ON ACTION

Researchers employed a third form of formal needs assessment known as reflection on action. The terms, *reflection on action* and *in action*, were described by Donald Schön [19] as one of the defining characteristics of a continuous learner. Schön, influenced by theorists like John Dewey, saw iterative reflective thought as a key feature of professional training because it encourages learners to spend time considering both individual and group interactions. The process of reflective thought demands that learners develop questions and ideas about educational practice – an essential step toward professional improvement. Reflection on action can be accomplished in multiple ways. After the teaching activity occurs, practitioners begin the process by reviewing a documented reflection such as a written or oral transcript, or videotape. Revisiting the images, ideas, and text that occurred in the past can help learners to explore why participants acted as they did or what might have been happening in a group. The resulting questions and ideas create a repertoire or guide for future teaching strategies and approaches to learning. Practitioners are expected to consider their conclusions and ask, "What steps will be done differently next time? The insights and professional knowledge gained from the reflective process is meant to ultimately become a clearly articulated and thus, explicit part of future decision-making.

Following Schön's theory, our reflection on action process began with a thorough review of two documented reflections - "training" machinimas of learners conducting virtual tornado rescue missions. The first machinima (T1) was filmed after three training sessions; the second took place during the last training (T2). The following observations are coded reflections of what was witnessed in one or both videos.

6.1. Q1 To what extent, were participants involved in a problem-based learning situation that encouraged self-direction towards learning?

Watching both training machinimas 1 and 2 (T1, T2) brought to mind the laughter and frustrations expressed by police officers, firefighters, and emergency medical workers as they learned to drive rescue vehicles around a city in the aftermath of the tornado. In one tornado session, in particular, an earnest ambulance driver rolled over a victim while trying to drive a patient to the hospital. Both T1 and T2 revealed evidence of problem-solving by each participant as the machinimas visualized the frenetic pace of the training, packed with activities and multiple events happening at once. Given that the tornado's path was unpredictable each session, participants could not anticipate where, for example, a fire hydrant might explode or a building fragment land. This contributed to the complexity of the problem-solving experience by making it new for all learners each session. Given the vast number of concurrent activities undertaken by all participants, it was surprising to realize that the location of each participant and comfort level in using virtual navigation tools could color one's perception of a problem. For example, if a reporter did not notice a fire break out near a building, he/she would not cover it in her live news report. Similarly, if a fire went unnoticed, a participant playing a firefighter will not try to put it out. Observations of T1 and T2 revealed at least two events, unnoticed by a participant/researcher at the time - the breakout of the fire (T2), and a bystander literally swept into the whirl of the tornado (T1). This concept of human error and the importance of how errors in the simulation transfer to life or death situations in the real world become apparent through the sense of experience as an avatar.

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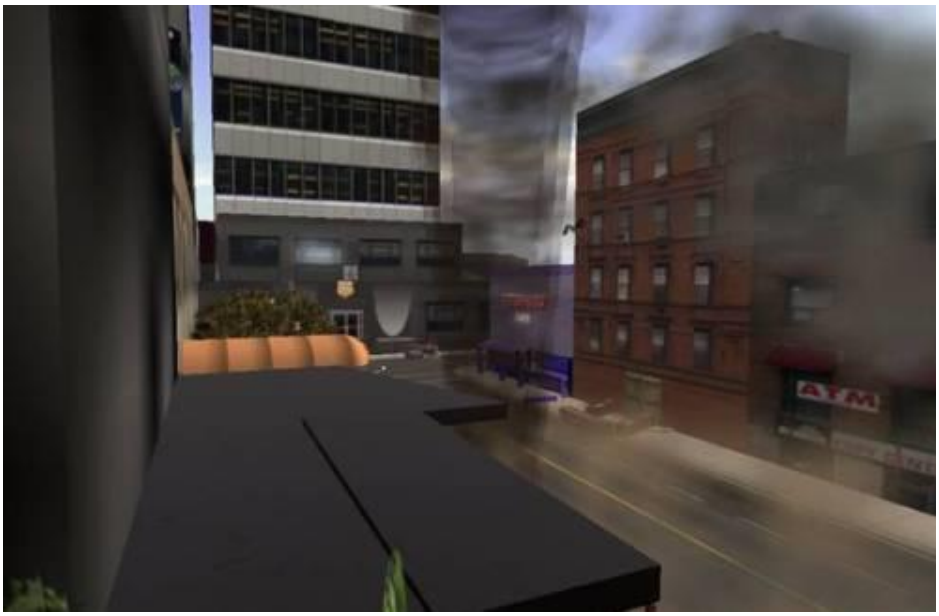

Figure 7: Simulated tornado moving toward city

6.2. Q2 To what extent, did learners exhibit prior knowledge, a "readiness to learn" and collaboration skills?

Prior knowledge was evident (and can be seen in T1and T2) as adult learners showed greater knowledge of, ease and familiarity with using the equipment and animations in T2 compared to T1. For example, those who played the victim in T2 used more of the available animations, such as the 'call for help' or 'writhing in pain' animations than those playing the same role in T1. Also, although not required by the role-play, rescue workers often boarded emergency vehicles in pairs, working together, to operate equipment vehicles, watch for injured victims, and aid them. Additional evidence of collaboration and readiness to learn can be viewed in T2 when avatars, such as the police officer, helped injured people who cried for assistance or EMS workers brought stretchers to those writhing in pain.

6.3. Q3 To what extent did participants exhibit signs of personal motivation, interest and active engagement?

T2 brought to mind the interest and personal motivation shown by participants as two individuals took to heart the role of a reporter and videographer. Both tried to interview victims throughout the role-play. At one point in time, a reporter was caught dismissing the rules of the role-play and sneaking underneath the protective yellow-tape barrier to 'get the story.' This behavior mimicked that of many local citizens and reporters who seek ways to capture information about a disaster, including pictures, videos and firsthand accounts, despite the possibility that their actions may put emergency responders, local citizens or even themselves at risk. In addition, the length of time each volunteer remained at the rescue mission, and persisted in working through technical problems also offered evidence of personal motivation and interest. In one training session, in particular, the personal interest and motivation of participants was tested as the builder (see acknowledgements) of the tornado simulations experienced a real-life emergency, delaying her arrival by close to 30 minutes, which meant the tornado could not be summoned. Despite the option offered to participants of leaving the rescue mission, everyone stayed until the builder arrived and continued the mission as planned.

The machinimas also brought to mind the effect of sound on the training. In both T1 and T2, the sound of wailing ambulance sirens and CB radio reports of police cars served to heighten the sense of urgency, time-sensitivity, and hence, active engagement of each participant.

Figure 8: EMS medic transporting victim

7. Discussion

7.1. Observation

All participants were involved in problem-based learning scenarios at some level; however, the type of problem was unique for each learner. Some roles presented higher levels of technical challenges while others relied on understanding the protocol undergirding that role. This clearly personalized the learning process as each individual had to figure out how to be both technically proficient and authentic in the role-play. In addition, each participant brought a different skill level and prior understanding of rescue missions to each session. Varying skill levels coupled with the unpredictable actions of each simulated tornado mission made each training session unique and required participants to exhibit cognitive flexibility as they adapted to new challenges. Observers also noted an increase in self-direction after participants selected an avatar role.

Given that all learners brought varying degrees of technical skills to the disaster training, all quickly realized they needed to learn from each other to move forward in the training. If a victim couldn't get onto the stretcher, the EMS worker had to help or no one would be successful in accomplishing their objective. The librarians involved in the exhibit, the builder of the tornado simulation, and all of the participants had to rely on each other for help, for collaboration, and for interaction to succeed in the experience. Each participant's role was interdependent and thus, learning from classmates became imperative. Participants seemed to operate comfortable in Vygotsky's ZPD throughout the training as evident in machinima scenes showing avatars crouching to help (paramedics or police avatars, for example) and victims awaiting help. The use of the private chat message feature inside Second, for those struggling with the interface, also aligns with the idea that learners are scaffolded throughout their individual ZPD. When struggling, users could use the chat to ask questions of each other privately, some of which is not documented but understood by the researchers as an option. This help from others, in any giving learning situation, shows that learning takes place at many levels of skills, knowledge, ability and understanding. Participants came from different time zones across the US to attend the training showing a clear readiness to learn. The prior knowledge participants brought to the training influenced their expectations. Those with more technical knowledge of emergency rescue operations tended to be the tornado geniuses that guided others while those with prior experience in emergency management influenced the protocol of virtual events.

High levels of engagement were witnessed throughout the training as participants lingered after the event ended, touring other types of 3D virtual world rescue operations. They appreciated the novelty of the training, the aesthetic beauty of the build, and the attention to detail in items like the authenticity of the CB radio messages. Authenticity of the simulation suggests realism and the ability to transfer the experience to the real world. Engagement also seemed present by the need to constantly collaborate with others. Personal motivation was evidenced by the chat and voice

questions; interest in and visits to similar builds; they wanted to learn more and were particularly intrigued by the high levels of interactivity embedded in the mission.

7.2. Interviews

Interviews with participants confirmed some of the initial observations of problem-solving in 3D rescue missions. Participants found problem-solving occurred at both the technical and role-playing level. They recounted their experiences as tense, stressful, and chaotic with multiple problems occurring at one time. For some with prior knowledge of real-life simulations, the virtual experience offered a semi-realistic accurate memory of how chaotic a real simulation can be and why trust in these situations is critical. They described having a greater awareness of and sensitivity to the difficulties faced by those he difficulties faced by those they role-played. The process of choosing a role, using the equipment, wearing the gear and clothing, and driving the vehicles helped each participant to identify with the role chosen. Through personal recollection, the individuals interviewed shared evidence of their involvement in the event as an experience rather than a body of knowledge to be learned. Several participants remarked on the level of detail in the recreation, which seemed to increase their engagement in the activity. The fact that the vehicles worked and could be driven impressed many and added to a sense of realism. They expressed engagement as an emotional attachment, such as 'virtual butterflies,' when problems seemed overwhelming. Some talked about feeling empowered to make decisions in the midst of the mission – such as shifting roles when it became clear that too many people had adopted a certain avatar type.

7.3. Reflection on action

Watching T1 and T2 machinimas recorded during the 3D virtual tornado rescue mission confirmed examples of elements of adult learning theory. However, both machinimas served as reminders of how the action, sound, and animation of the virtual world work to heighten user engagement. The importance of visualization and sound during simulation through objects (vehicles, uniforms, buildings, streets) and through movement (animation of the avatars and scripting of the falling debris) added a compelling sense of urgency and realism to the event. In addition, although both machinimas confirmed earlier observations of collaboration, they also led to another layer of analysis. Seeing the larger view of the tornado rescue mission made it clear that individual problem-solving was limited to what one saw at the time of the event. Given the capricious nature of the tornado and the vast number of events happening at once, it was clear that what one avatar sees as a problem may not be noticed by another. Comparing machinimas also yielded the realization that more animations occurred in the second machinima than in the first one. This realization would imply exposure to earlier tornado rescue missions helped participants to grow more comfortable with using animations, thus making it easier for more animations to be used and thus, captured on machinima the second time around.

8. Limitations and future research

While all participants showed evidence of engagement in problem-solving, clear learning objectives were not stated at the beginning of each session. As a result, some participants expressed uncertainty in what they were supposed to learn. Participant 7 [30] stated, "I didn't know what SL was before this event so I learned something. That was interesting. I'm not sure I learned anything about management. It never occurred to me that VW could be used as a training tool in SL." Without directly stating what a learner is supposed to derive from training, it becomes harder to measure if targeted learning goals were achieved. However, it is important to note that participants' technical skill level and prior knowledge of disaster training varied widely. For some, the mere act of entering into a virtual world was a new experience. Thus, even if learning goals were set for the disaster training, it is likely a newcomer to virtual worlds would focus more attention on the medium, itself, than on the medium's training objectives.

As mentioned in the discussion, learning to navigate the user-interface posed an additional problem for new users. If future training objectives focus on practicing specific role responses to disasters, making sure all participants enter the disaster training on an equal technical footing is critical.

Only portions of the simulations were captured in machinima footage. Because T1 and T2 are edited

machinimas and do not include every moment of simulation, all of the participants appear to have equal knowledge and skills. Back-channeling (behind the scenes conversation, such as instant messages or frantic calls for help with the platform) is not visible in the machinimas.

Finally, the number of session participants and training events limited the scope of this study. One cannot assume that the results of this virtual world disaster training would be replicated in other virtual world trainings given possible variations in teacher practices. More research with greater numbers of participants in different types of virtual world training events is needed. If the study is large enough, possible variations in implementation that might skew the results of virtual world training on student learning could be identified as independent variables and tested statistically.

9. Conclusion

This study provides evidence that 3D virtual worlds are useful for role-play simulation and align with classic tenors of adult learning theory. Virtual world trainings offer a "sense of presence" and engagement that shows potential for training in emergency management preparedness and rescue training. Three elements of adult learning theory were strongly evident: a problem-based learning situation that encouraged self-direction towards learning; prior knowledge, a “readiness to learn” and collaboration skills; and signs of personal motivation, interest and active engagement. These findings may be useful for future simulations in areas of emergency management or other trainings that may be difficult or dangerous to simulate in the physical world.

Just as earlier studies, such the role-play of a family facing euthanasia, this study showed evidence of participants expressing the feeling of realism in a simulation, applicable to numerous real world situations. A 3D virtual environment role-play of emergency rescue scenarios provides participants an immersive experience in a "life or death" simulation, which can be classified as serious gaming. The study used volunteers with various skill levels in both the 3D virtual world of Second Life and real life rescue experience and the findings provide evidence of alignment of virtual world simulations with Adult Learning Theory.

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