Leveraging a Virtual Environment to Prepare for School Shootings

Tami Griffith[1(✉)], Jennie Ablanedo[2], and Tabitha Dwyer[3]

[1] US Army Research Laboratory, Human Research and Engineering Directorate, Advanced Training & Simulation Division, Orlando, USA
tamara.s.griffith.civ@mail.mil
[2] Institute for Simulation and Training, University of Central Florida, Orlando, FL, USA
jablaned@ist.ucf.edu
[3] Cole Engineering Services, Inc., Orlando, FL, USA
tabitha.dwyer@cesicorp.com

Abstract. Active-shooter incidents within a school setting involve a unique subset of active-shooter events. These events tend to have significant differences in duration and outcome to events that occur in other locations, often being resolved before, or when, first-responders arrive on the scene. The frequency and seriousness of these events inspired the US Department of Homeland Security, Science and Technology Directorate's First Responder's Group (DHS S&T FRG) to leverage ongoing work with the US Army Research Laboratory, Human Research and Engineering Directorate, Advanced Training & Simulation Division (ARL HRED ATSD) to establish a prototype virtual school environment to prepare teachers, administrators and staff on how to respond and work with Law Enforcement (LE) in the event of a school shooting. This virtual platform allows school staff and LE to practice various strategies and even supports analysis into how different security measures within the school environment might change the dynamic of an attack and response. The goal is to train affected groups together in advance of an attack to improve coordination and reduce response time and casualties. This paper illustrates design choices for training school teachers, administrators and other staff in a virtual environment in the event of a school shooting. These choices demonstrate unique development strategies related to controlling Artificial Intelligence (AI) through simple user interfaces, managing crowd behaviors and ultimately will include the ability to apply game engine level rules to different buildings or maps.

Keywords: School shooting · First responder · Virtual training · Crowd control · Game engine

1 Introduction

On April 20, 1999 a shockwave moved across the United States as two high school students perpetrated a well-planned attack on Columbine High School. The students used two 9 mm firearms and two 12-gauge shotguns, which were sawed down to a concealable

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size, along with 99 improvised explosive devices [1]. The explosives were used as a diversionary tactic to distract first responders, then later to drive frightened crowds toward the attackers [2]. This horrific tragedy shocked the nation and drove law enforcement to re-examine antiquated response strategies [3]. Sadly, the event also inspired other potential attackers eager to achieve infamy by perpetuating further tragic events, such as the Virginia Tech massacre in 2007 where 27 students and five faculty members were killed [4]. More recently, on December 14, 2012, the world stood helpless as 20, six- and seven-year-olds were killed, along with teachers and administrators, at Sandy Hook Elementary in a time spanning five minutes and ending with the shooter's suicide [5] (Fig. 1). The police arrived a few minutes after the final shot, unaware of the number of attackers or the dangers or horrors they would find [6]. These active shooter incidents heightened awareness of the threat of violence towards children on campuses nationwide (Weatherby, 2015). The lessons learned from these horrific tragedies have prompted a greater demand for effective training against active shooter events within a school setting.

Fig. 1. Connecticut state police lead children from the Sandy Hook Elementary School [7].

Given the gravity and the unpredictable nature of the threat it is critical that schools train and prepare for potential active shooter events. Also, given that over fifty-seven percent of school shooting incidents are over before law enforcement arrives, lasting, on average, 12 min, and ending (55% of the time) with the attackers committing suicide, [8] teachers and school administrators must train as unarmed first-responders. Current training and drills include practicing lockdown and evacuation procedures for a variety of scenarios [9]. School administrators and staff work to anticipate and prepare for a variety of potential emergencies with an emphasis on consistent crisis plan customized for the geographic, economic and social standards [8]. Figure 2 is a snapshot that shows a breakdown of active shooter events by location, indicating that nearly a quarter of active shooter incidents between 2000 and 2013 occur in an educational setting.

The Federal Emergency Management Agency (FEMA) describes Active Shooter and Mass Casualty Incident (AS/MCI) as "involving one or more subjects that participate in a random or systematic shooting spree, demonstrating their intent to continuously harm others" [10]. MCIs are significant events that normally require coordination between on-scene fire/rescue/medical and LE with Unified Command (UC) being the

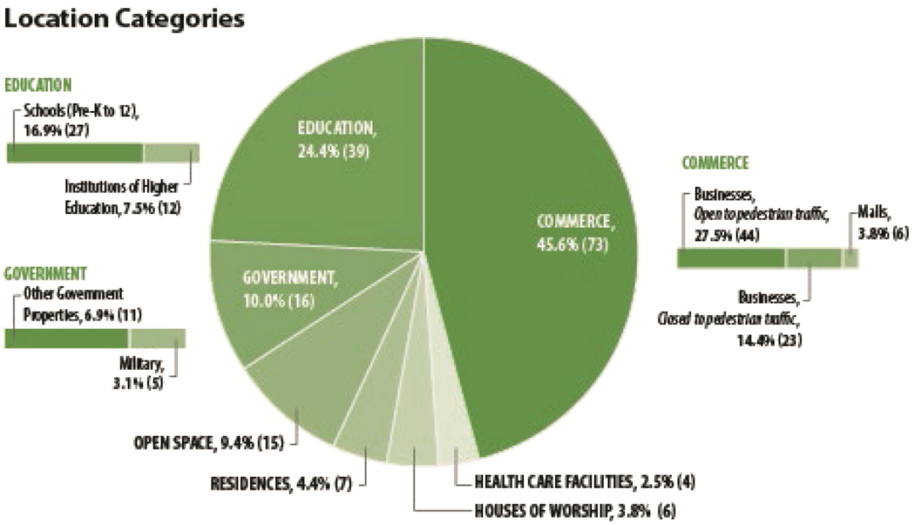

Fig. 2. Study of 160 active shooter incidents in the United States between 2000-2013 [11]

vehicle for command and control of the event through a Unified Command Post (UCP). Due to the rapid escalation and resolution of school shooting events, the UCP will likely not stand up until late in the timeline, meaning that a swift and coordinated response with meaningful communication will need to be established in advance of receiving guidance from command and control.

The information above sets the stage for the purpose behind the design of training capability. Using information gathered from reports on active shooter incidents and updated tactics has shaped the design for a virtual environment designed specifically to train school faculty and staff in the event of an active shooter incident within a school setting. The unique development strategies associated with the training environment is the focus of this paper.

2 Background

Following the successful implementation of a virtual environment that supports cross-service training for a complex coordinated attack, similar to that seen in Mumbai, India in 2008 [12, 13] it was apparent that there was demand for training to support the unique needs of a school setting. The Department of Homeland Security Science and Technology Directorate's First Responder's Group (DHS S&T FRG) along with the US Army Research Laboratory, Human Research and Engineering Directorate, Advanced Training & Simulation Division (ARL HRED ATSD), reached out to experts from Educator's School Safety Network to draw from existing data and lessons-learned to establish requirements for training within a school shooting scenario.

Historically, school staff are passive supporters to LE training for active shooter events [14]. However, based on the issues described above, it was determined that school

administrators and staff are on the front lines of defense against active shooters and therefore must be part of response training. Although virtual training cannot replace the complex interactions involved in live training, live events are rare due to the logistics involved in securing a facility, accessing live actors and coordinating a myriad of interdependencies. When live events do occur, they are infrequent with only a very small fraction of potentially affected parties taking part. Virtual training simulations allow a large number of responders to train repeatedly, both as individuals and in teams potentially increasing the depth and breadth of trainee involvement since exercises can be repeated at a fraction of the cost of a live event and can be used to prepare trainees to make better use of live training time.

DHS S&T FRG looked to leverage previous work to reduce cost without sacrificing performance. By leveraging the established partnership with ARL HRED ATSD, DHS built upon the Enhanced Dynamic GeoSocial Environment (EDGE) (Fig. 3). This is a Government-owned platform making use of both the Unreal 3 and Unreal 4 game engine. The use of a game engine reduces development time, compared to traditional simulations, and leveraging efforts from other Government agencies helps to reduce overall costs.

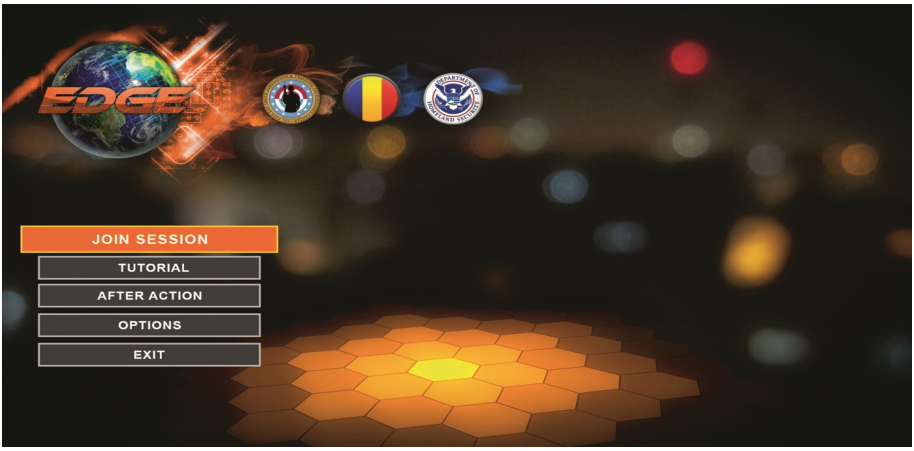

Fig. 3. The enhance dynamic geo-social environment start screen in Unreal Engine 4

Individuals from the commercial modeling and simulation industry, academia, ARL HRED ATSD, and DHS S&T FRG along with first responders, school board members and a representative from Safe and Sounds Schools came together to establish detailed requirements to support training. The result is a virtual training prototype to be used to support a training exercise for first responders, including faculty and school staff, in response to active shooters in a school setting.

3 Stakeholder Goals

The primary stakeholders for this effort include the DHS S&T FRG, the ARL HRED ATSD, first responders and school administration and staff. Each had their own unique perspective to lend to the end product. Support in the development of this capability was

provided by both academia - University of Central Florida, Institute for Simulation and Training (UCF IST) and industry (Cole Engineering Services, Inc.).

3.1 Department of Homeland Security Science and Technology First Responders Group

DHS S&T FRG has recognized a considerable increase in the number of active shooter events taking place in educational settings in the United States and world-wide. As a result, they turned their focus toward establishing a training tool to better prepare for this eventuality and to close the training gap between school staff and LE.

The requirements called for readily-accessible, high-fidelity simulation tools to support a training exercise not only for first responders in incident response and management but also for school staff who would function as first responders prior to LE arriving on the scene of an incident. This simulation allows large numbers of school staff to train repeatedly either at a common location or distributed. Teachers and administrators from multiple agencies, disciplines, and jurisdictions would be able to train for a coordinated incident response and have the flexibility to integrate location operational tactics and procedures.

3.2 School Administrators and Staff

In the case of LE officers, experience improves survivability. This applies to soldiers as well. This is why the Army invests heavily in simulations to build experience in a safe environment. A simulated experience ensures that the first time school administrators and staff experience a life threatening event they can use the experience to learn and improve their response if faced with a threat in real life. The environment can also be used to assess how schools might implement safety measures, testing various door locking strategies (lock from inside, automatic locks, etc.) while in the safety of a simulation to determine what works best (Elsass, 2016). A virtual environment provides a safe space to strategize using different theories and to provide training to educators to turn theory in to practice. The Educator's School Safety Network was founded to give educators a voice in critical school safety conversations. Their mission is to help keep schools safe by providing training, services and resources to educators, administrators, school-based law enforcement, and other stakeholders.

Administrators and staff must be able to train at the tribal, local, state or federal level, allowing varying authorities and policies. The training platform provides a training capability that prepares school teachers and staff from a small school house in Oklahoma to a larger school in New York City. The high-fidelity simulation supports training and exercise for large numbers of school staff to train repeatedly, both as small teams and alongside multiple agencies, disciplines, and jurisdictions as a coordinated incident response and have the flexibility to integrate location operational tactics and procedures with synchronized (not just coordinated) efforts of all groups.

3.3 Army Research Laboratory Human Research and Engineering Directorate Advanced Training & Simulation Division

US Army ARL HRED ATSD, specifically the Advanced Modeling & Simulation Branch, is exploring the use of commercial game engines to improve training in support of various tasks. In pursuit of this goal the Enhanced Dynamic Geo-Social Environment (EDGE) was born. The team responsible for EDGE holds firm to the belief that the Government should own the source code for training capabilities and that it should be shared across all Government organizations and agencies. By having Government rights to the source code of commercial technology, experts can develop specific functionality and make it available to others at no additional cost. For example, tactical movement with a weapon is very similar across the Army and first responders. This capability doesn't need to be created new for each new user of the environment. However, new functionality, such as the use of naturally propagating fire that has realistic damage effects on characters and the environment, can be developed once and reused by various agencies. The more agencies that utilize and develop on the architecture the greater the benefit.

EDGE prototypes are developed as part of an overall goal to reduce potential development risks, such as performance limitations while assessing the training effectiveness of prototypes in the test bed. The EDGE team has established a kind of game technology incubator in their game lab, inviting other Government groups to participate in development alongside the team to gain knowledge and experience which they can then bring back to their own labs for reuse.

The goals for this project were to evolve previous work, completed in Unreal 3, into the robust development tool provided by Unreal 4 using the same business model for cost efficiencies. There are many benefits in designing the school within UE4. For example, the engine contains higher graphical fidelity through advancements in rendering efficiency and physically based materials. It has the ability for rapid prototyping using the new UE4 Blueprint system (visual scripting, no code). Unreal 4 has improved developer tools for animation, materials and visual effects. The ability to separate project source code from engine source code make it easier to maintain currency and reducing development and build times [15]. Much of the original models and artwork created in Unreal Engine 3 were leveraged to support this new work.

By making use of tools that the Army can benefit from, overall development costs for each contributor are reduced. Most importantly, all products are available at no cost to end-users with no limit to the number of user seats.

One of the greater costs of training can be bringing the students to the training event. Sometimes the instructor is brought to the students to reduce costs. One goal for the Army is to make training available at the point of need. Students do not need to be co-located with the instructor. The technology allows for local or distributed exercises. The environment can be available to train 24 h a day, seven days a week.

The EDGE team also conducts research into various user interfaces. The game architecture allows for a wide breadth of flexible user input, quite often in a plug-and-play fashion. The use of simulated weapons, game controllers, floor pads, head-mounted displays and wearable technology can all interface into the environment.

Both DHS S&T FRS and ARL HRED ATSD felt that a graphically-rich, high fidelity environment would make training more realistic and believable while meeting the expectations of the generation of users who have been brought up with high fidelity games at their disposal.

4 Design Decisions Based on Stakeholder Needs

Characters. Figure 4 shows the character selection screen. Each role and its design attributes are described below.

Fig. 4. Character selection screen for school scenario

Teachers. Teachers play a vital role in emergency response of a school shooting incident. Teachers keep students calm during an emergency and protect their students. It is vital for a teacher to be prepared and to practice making use of their various options. Design decisions associated with this role are described below.

The teacher character role is equipped with a master key to access all playable rooms. Teachers have the ability to direct (or control) Artificial Intelligence (AI) students. They have a list of commands such as "line up against the wall," "leave through that window," "hide," and "follow me" (Fig. 5). Teachers can also communicate with the rest of the school a Public Address (PA) system by accessing the intercom on the walls of classrooms. Teachers enter the environment by selecting a room which will then be filled with students.

Staff Roles (Administrators and other staff). The school administrator role is equipped with a master key. They have ability to speak to teachers over the PA system from the intercom in the front office. Staff can also give orders to the AI students. This role differs from teachers in that they do not start the simulation within a classroom.

Fig. 5. User interface to control students

Law Enforcement Officers (LEO). The law enforcement roles is equipped with a Taser, an assault rifle, a handgun, and a shotgun (Fig. 6); all weaponry has limited ammunition. They are protected with a bullet proof vest and a helmet. Careful consideration was applied to the police role for this particular scenario and will be discussed later in this paper.

Fig. 6. Law enforcement officer's load out

School Resource Officer (SRO). School districts and local law enforcement are increasingly teaming up to ensure that more campuses have a law enforcement presence [16]. The use of campus security and police officers has been an excellent resource for supporting the school systems. These security personnel are known as School Resource Officers (SROs) and are assigned to a school or school district. This role is similar to an LEO role except for the weapon load out and the starting location.

Suspect Roles. The suspects drive the scenario. Their activities determine the response. Suspects are played by live role-players to allow for a wide range of scenario support and to avoid learners getting to know AI activities and "gaming" the training event. The suspect role is equipped with an assault rifle, a handgun, a shotgun, extra assault rifle ammunition and a pipe bomb. Since statistics show that 55% of the time an active shooter will commit suicide after the act is committed [17], this would be an additional capability for this role; allowing the suspect to commit suicide within the simulation.

Students. Although most students are represented as AI, as described in the next section, participants may also choose to enter the environment as a student. A live role player in the student role can either help or cause chaos as defined by the exercise control team. Since they will also be able to communicate with others via voice, they can give helpful or misleading information to trainees, affecting the course of the scenario.

Non-Player Characters and Artificial Intelligence. Because of the importance of crowds in a school environment, multiple Non-Player Characters (NPC's) are used to establish realism and, in some cases, chaos. This gives role players more people to interact with and protect. Character roles, such as teachers, administrators and LEO, have the ability to manage NPCs within the scenario allowing for a more fluid and realistic experience. The crowds can add to the chaos within the school, as well as allow for teachers and staff to practice what orders they would give to those they see roaming in the hallways or in the classroom. For example, each NPC has a panicked state that will randomly trigger the character to flee and evacuate, hide or stay in place. These triggers transition into behaviors after the NPC detects more than two gunshots, they see a law enforcement officer equipped with a weapon, or they detect a suspect equipped with a weapon.

Artificial Intelligence (AI) drive the NPC's to take commands from various player characters (teacher, administrator or LEO). For example, the NPC's can transition to an orderly evacuation from an alarmed state when given the command to evacuate via the nearest rooms, doors, or windows.

Game environments support a wide spectrum of realistic qualities. Three-dimensional sound can help trainees determine where shots or shouts are coming from. Players expend stamina while sprinting, breaking into a walk when stamina is exhausted. The level of gore presented can be ramped up or scaled back depending on the training value for that particular training audience. In the first iteration of the school scenario, the amount of blood that would be visible was scaled back to be sensitive to emotional reactions from teachers and staff. In future versions this will be a configurable option for each exercise.

Each player has an indication of damage state. The physics and vulnerability models determine whether a character is injured, stunned, armor damaged, incapacitated, or dead based on a number of factors including weapon used, whether armor was equipped, and the exact location where the impact occurred.

4.1 The Environment

The simulations allows for future growth and scalable numbers of participants. The architecture allows various locations to be modeled using the same "game rules." Game rules establish how players interact with the environment and one another. As game engine technology advances it is leveraged and applied to the level to maximize the government investment. Using commercial game technology was expected to improve participant engagement. The actual school used in this scenario is shown in Fig. 7.

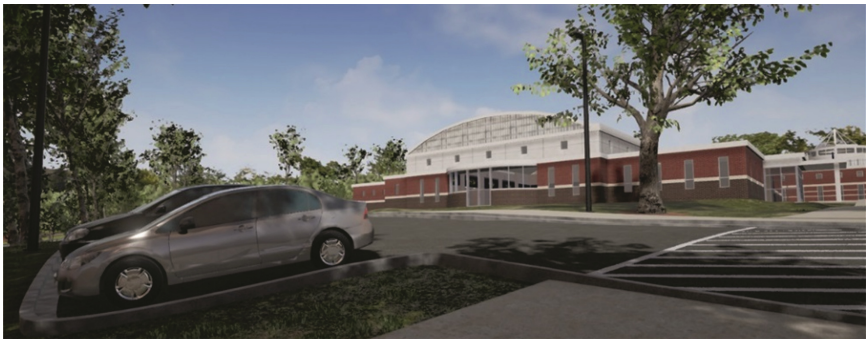

Fig. 7. Outside view of the school

5 Conducting an Exercise

There are quite a few moving parts that must work together to establish a training exercise. This section outlines an important subset.

Communications have to be realistic with local proximity noise and voice communication as well as radio communication across various tactical channels. Proximity talk is accomplished by simply talking into the player headset, while radios are "keyed" using the space bar. The school intercom is operating by interacting with the intercom box on the wall of the classroom (activating the "F" key when in proximity to the intercom box).

Trainers capitalize on teachable moments by observing individuals during and after the exercise. This can be accomplished by being an invisible viewer in the environment in real-time or by playing back the exercise and viewing it from each character's perspective through the After Action Review (AAR) tool. This tool includes synchronized capture and playback of all local, radio, and PA voice communications.

Each individual role player needs a computer with a graphics card to display the high-fidelity graphics, however, the computer does not need to be new or state-of-the-art. Computers that meet the needs of the software are generally under $1,000 by current market standards. Training can also be conducted in a distributed manner with trainees participating from their geographically separate facilities.

Most importantly, this training tool is not made up of a small handful of scenarios. Instead it allows for a multitude of scenarios. This is referred to as a "sandbox" approach, meaning that the virtual environment could support any variation of possibilities from

an individual shooter to multiple intelligent shooters with incendiary devices. Actions in the environment would be managed through an exercise control cell who dictates the actions of individuals in the role of the attackers [18]. The simulation encourages teachers, administrators, and staff to train together while applying their own doctrine or Standard Operating Procedure (SOPs). Consider one jurisdiction where the policy is that the first individual on the scene of an active shooter event must wait for backup before engaging shooters while another jurisdiction requires responders to move to stimulus immediately. The virtual environment allows all possible responses. Interactions are not scripted, and just like real-life, anything can happen. This means that events in the environment can and will get very messy and complicated with miscommunication and chaos. The intent is that mistakes or learning moments happen in the virtual environment rather than while actual lives are at stake.

When conducting a virtual exercise it is important to establish familiarity with the virtual tools and how to navigate within the environment prior to starting an exercise. Participants receive a briefing on the intent of the training and a description of how they enter and navigate the virtual environment. The participants break out into their specialization groups and receive a tutorial explaining how to use their role-specific capabilities within the environment. After the tutorials, participants enter the environment and engage in familiarization activities. Participants are encouraged to explore the school and practice using their weapons and communications. This often looks like play, but is a critical element for them to build familiarization with the tools available prior to the serious task of the learning exercise.

6 Challenges and Mitigation

There has been a small amount of research on best practices for school-based crisis planning with little hard evidence to indicate what will work in the event of a crisis (US Department of Education, 2003). A simulation allows research to be conducted in order to identify strategies to overcome policy gaps, and to establish best practices to ensure the safety of children. At the same time, emergency plans and procedures cannot follow a one-size-fits-all model. Flexibility is essential if lockdown and evacuation drills are going to be effective [9]. Using commercial game technology, an individual joins a team to accomplish a complex task. The team can be distributed anywhere around the world. By utilizing the sandbox model in the virtual environment, a variety of scenarios can be performed to not only rehearse use cases, but to allow for simulations to be performed setting policies for different geographic areas.

Running an exercise as a training event is not like traditional course work. Sometimes, there is no “correct response.” Sometimes the correct response is purely defined by the outcome and can only be assessed retrospectively. Take for instance the decision by the Kenyan security forces to delay entering the Westgate Mall, while plainclothes civilian rescuers and plainclothes police rushed in to engage terrorist attackers [19]. The decision by the impromptu group could have endangered existing response activity or it could have saved considerable lives. Retrospectively, given the lack of State response the civilian response may have been warranted. In order for an exercise to become a

learning event, it is critical that observers be present to make note of actions at every level. For example, if the LE observer sees activities that violate doctrine, they are played back and discussed during an AAR. Each component of the response team should receive a review of their performance during the exercise, then the larger team receives feedback on how the components worked as a team. Strengths and opportunities for improvements are highlighted and discussed. This is also a good time to discuss if protocols should be re-examined. After the exercise has been thoroughly reviewed, participants have the opportunity to apply the learning by running another exercise [13].

Training for mass casualty events is often focused on one or two components of the event to simplify and focus training. For example, LE may focus on finding an active shooter to stop the threat. However, they may not train on the events that follow, such as clearing the area and preserving evidence. With a virtual environment every activity associated with the response to an active shooter incident can be exercises. Details such as the control of traffic, the placement of the Incident Command Post (ICP) – that can bring about success or failure in an active-shooter incident, even tactics from historic events [20] – can be modeled in the virtual environment.

7 Way Ahead

Work has already started on the next iteration of the EDGE First Responders Sandbox School training level that will add emergency medical and fire fighter roles. The next iteration will include the ability to edit the scenario to start at various times of the school day. Before school starts, students will be in crowds in gathering areas inside and outside the building. During lunch, the bulk of students will be in the cafeteria. Other enhancements will include the ability to adjust door type (lock inside, lock outside, auto lock, swing in, swing out, etc.), whether there are Public Address Systems or intercoms, as well as many other options, such as the use of cell phones for communication. It will also be possible for trainees to fight back unarmed, including punching and throwing objects.

8 Conclusion

Active-shooter incidents within a school setting are a unique subset of active-shooter events. This concern inspired development of a prototype virtual school environment to prepare teachers, administrators and staff on how to respond and work with Law Enforcement (LE) in the event of a school shooting. This environment will be made available at no cost to the training audience to improve survivability of this threat. The team made use of the Unreal Engine 4 to quickly prototype a training level using development and modeling tools to manage crowds and apply various response strategies in the event of a school shooting. These strategies can be used to explore how different security measures within the school environment might change the dynamic of an attack and response.

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