SIMEX 20-6 After-Action Report

School Security

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EXECUTIVE SUMMARY

Simulation Experiment (SIMEX) 20-6 was conducted from August 3 to August 14, 2020, to explore casualty mitigation during an active assailant event in a suburban high school in the United States through virtual reality experimentation. The Department of Homeland Security's (DHS) Cybersecurity and Infrastructure Security Agency (CISA) sponsored this event in coordination with George Mason University's (GMU) College of Education and Human Development. The SIMEX modeled general school policies related to security during an active shooter event, simulated those policies through repeated experimental runs in a virtual reality environment, and generated data to determine their impact on the outcome of a school shooting scenario. SIMEX participants included teachers, students (played by GMU students simulating K-12 students), school resource officers (SRO), and a front office administrator.

This SIMEX investigated the impact of three factors on an active shooter scenario:

- **Factor 1 – Presence of SRO:** Whether an SRO was present and patrolling in the school or absent.
- **Factor 2 – Door-Locking Policy:** Whether classroom doors were pre-locked or had to be manually locked during lockdown.
- **Factor 3 – Lockdown Notification Policy:** Whether lockdown notifications were decentralized (could be made by teachers over public address system [PA]) or centralized (could only be issued by front office).

One participant played the role of the shooter, who was a current student of the simulated school. The SIMEX included both targeted and mass casualty shooting scenarios to account for a variety of known and documented shooter behaviors.

Experiment Purpose

Conducting this SIMEX 20-6 served two primary purposes. The first was to examine the above factors to develop recommendations to improve both physical and operational security in K-12 schools across the nation. The second was to evaluate the SIMEX platform to determine if it is an effective tool to evaluate school safety-related policies, technologies, and procedures in the future. In addition to the key findings and recommendations from this SIMEX, there are also documented takeaways that discuss the use of SIMEX as a tool included at the end of this section.

Experiment Structure

Following three days of training and system testing, experimental trials ran August 6 to 14 with typically six runs a day in order to collect enough data to precisely measure the effects of the factors of interest. Each run consisted of a participant briefing, setup, scenario execution, a post-run survey, and a post-run discussion.

Scenario

The SIMEX scenario was set in a virtual high school environment modeled after designs used in current day schools supporting 1,000 students. To accommodate the relatively small number of live participants in the experiment, just a section of the representative high school was modeled in the virtual environment using architectural best practices for school design. Each run took place at 7:45 a.m. to simulate the period in the school day involving school arrival and classroom transition activities.[1]

Roles and Assignments

The simulated school was populated with 10 human-operated teachers and 20 human-operated students, as well as more than 300 non-player character students to fill out the student body. A human-operated school administrator handled communications through the front office. In several of the runs, a human-operated SRO patrolled the school. Participants were recruited based on their real-world experience in these roles.

At the scenario start, operators were instructed to perform actions that model a school morning. Ten of the classrooms were designated homerooms. Each teacher was assigned to a homeroom, one teacher per homeroom. Two human-operated students were also assigned to each one of these homerooms.

[1] Determined from data indicating that three quarters of school shootings occur in the morning before or during classes. [9]

Prior to a threat, students and teachers were given assignments to circulate around the school on the way to their homerooms. During a threat, all participants were instructed to follow lockdown procedures as assembled from best practices of real school emergency procedures.

For each run, the shooter's mission was to either target a particular homeroom teacher or inflict as many injuries as possible. Analysis found that varying the shooter's mission had no significant effect on scenario outcomes in this experiment.

Data Collection and Analysis

To measure scenario outcomes, data was collected by automated event logging during the simulation as well as participant responses to post-run surveys. Quantitative measurements to evaluate each run included (but were not limited to):

- Casualties as percentage of total population
- Percentage of students "safe"—either evacuated or in a locked classroom
- Average time for homerooms to complete lockdown (close and lock doors) and number of homerooms completing lockdown
- Situational awareness, workload, and stress as reported by the participants in post-run surveys

In addition to the quantitative metrics, qualitative data was collected in the form of survey content and was analyzed to explore participants' attitudes and responses. SIMEX staff also observed the behavior of key participants during scenario execution.

Findings

Factor 1 Findings: Presence of an SRO

In half of the experimental runs, a human-operated SRO patrolled the school. The following statistically significant[2] results emerged from this factor:

- On average, **casualties were 7 percent of the total population when the SRO was present** as opposed to **13 percent when the SRO was absent**.
- On average, the **shooter discharged 52 percent of ammunition when the SRO was present** as opposed to **91 percent when the SRO was absent**.
- On average, **26 percent of students achieved safety when the SRO was present** as opposed to **18 percent when the SRO was absent**.
- On average, **50 percent of homerooms (5/10) completed lockdown when the SRO was present** as opposed to **30 percent (3/10) when the SRO was absent**. In survey feedback teachers reported closing their doors when they saw the SRO was nearby.

Factor 1 Conclusion

The presence of an SRO was found to have a significant impact on the outcome of an active school shooter event. In runs with an SRO, more students got safely outside the school or into locked classrooms and there were fewer casualties than in runs with no SRO.

Factor 2 Findings: Door-Locking Policy

In half of the experimental runs, classroom doors were "pre-locked," meaning they were locked automatically when closed. In the other runs, teachers had to manually lock doors by pressing a locking mechanism on the outside of the door in the virtual environment for a randomized time between 3 and 6 seconds. The manual lock would not engage if the locking process was interrupted during this time. This mechanic was intended to emulate the time needed to operate a keychain and keylock or keypad lock while experiencing the stress of an active shooter event in the school. The runs with pre-locked doors yielded the following statistically significant results:

[2] Findings that are statistically significant refer to those in which it would be extremely unlikely for that effect to be due to chance. Based on an analysis of the experiment data, these are the findings that can be reported confidently.

- On average, **26 percent of students achieved safety when doors were pre-locked** as opposed to **18 percent when doors had to be manually locked**.
- On average, **50 percent of homerooms completed lockdown when doors were pre-locked** as opposed to **30 percent when doors had to be manually locked**.
- In survey and post-run feedback, teachers mentioned feeling frustrated and unsafe when faced with the manual locks.
- On average, **homerooms were locked 43 seconds before threat onset when doors were pre-locked** as opposed to **15 seconds after threat onset when doors had to be manually locked**. This difference is explained by the observation that teachers closed their doors when they decided to start class, which in the case of the pre-locked doors would lock them as well.
- **Casualties were not significantly affected by door-locking policy in this experiment**. Though more students were presumably safe behind locked doors, the shooter's casualty count was similarly high in both locking conditions. In this experiment, the shooter adopted a strategy of entering a classroom with the weapon concealed before the door was closed and locked. If the shooter had adopted a different strategy, the increase in student safety may have led to a reduction in casualty count. In addition, a few participants mentioned being shot by stray bullets through walls.

Factor 2 Conclusion

Classroom doors that lock without teacher intervention when closed were found to have a significant impact on the outcome of an active school shooter event. In runs with pre-locked doors, more classrooms completed lockdown procedures and more students got safely outside the school or into locked classrooms.

Factor 3 Findings: Lockdown Notification Policy

In half of the experimental runs, lockdown notifications were "decentralized," meaning that teachers could use the PA system to alert the whole school of an active shooter incident taking place. The other runs were "centralized," meaning that teachers reported the incident directly to the front office whereupon the school administrator made a formal notification of an active shooter event over the PA system. In both cases, the front office administrator responded to teachers' reports by issuing an official lockdown announcement over the PA system to the whole school. After the initial announcement, teachers continued to issue notifications on the shooter's location and description using the PA system or to the front office, respectively. The quantitative metrics did not indicate any significant effect of lockdown notification policy in this experiment. The following are notable results regarding the lockdown notification process:

- The **SRO reported consistently high situational awareness in runs with decentralized notifications** (average Situational Awareness Rating Technique [SART]) score 35 as opposed to 29; SRO's situational awareness ranged from 23 to 38 over the course of the experiment).
- In post-run survey feedback and hotwash feedback for centralized runs, the **SRO noted that information in the notifications lagged behind the shooter's actual location**. Analysis of survey content showed teachers felt decentralized notifications were more reliable.
- In post-run survey feedback, the **shooter described taking advantage of PA announcements to avoid the SRO and to surprise potential targets**. This was confirmed by observing the shooter's behavior.

Factor 3 Conclusion

Allowing teachers to give lockdown notifications over the PA system (the decentralized mode) did not have a significant impact on the outcome of an active shooter event in this experiment.

Related Findings

Shooter and SRO Interaction

The shooter eliminated the SRO in 11 of the 12 runs in which the SRO was present. While this result was due in small part to artificialities associated with the SRO's inability to confront the shooter in a realistic way (e.g., visual cues, non-lethal restraints), the shooter was generally able to target and eliminate the SRO before the SRO was able to engage the shooter.

Two trends emerge from the quantitative and qualitative analysis. The first is that the shooter's situational awareness is both timely and sufficient whereas the SRO's situational awareness is both late and insufficient. The second is that the shooter's mental workload is less than that of the SRO. Both of these indicators contribute to the success of the shooter over the SRO in direct confrontation.

Recommendations

School security stakeholders should consider the following recommendations drawn from conclusions to mitigate the effects of school shootings. These recommendations are not prioritized (CISA does not recommend one recommendation over another) and it is critical that each be considered in accordance with state and/or district requirements and regulations as well a school's existing policies, procedures, and operations. Furthermore, the recommendations were developed based on data analysis evaluated within the scope of the specific scenario described earlier in this section.

1. The presence of an SRO in this experiment reduced casualties and increased the number of students able to remain safe during an active school shooter event. As a result, **schools should consider the use of an SRO or equivalently trained security professional(s)** as a component of a layered security approach.
2. While an SRO's presence improved the safety of students and teachers during lockdown, their situational awareness was not sufficient to neutralize the shooter in an active shooter incident. To address this challenge, **schools should investigate potential strategies or technologies that improve the timeliness and accuracy of an SRO's** (or external law enforcement's) **situational awareness** to support the observing, processing, and decision-making process.
3. Given that pre-locked classroom doors may increase the number of students able to remain safe during an active school shooter event, **schools should consider establishing a policy to require that classroom doors be kept in the locked position at all times** during morning, daily, and departure periods where possible. Alternately, **schools could also consider adopting technology for automatically locking all classroom doors** when a lockdown is issued. Such a policy and/or technology could play a role in developing an effective, comprehensive security strategy.
4. A lockdown notification policy did not yield any clear effects in this experiment due to the finding that while decentralized notifications may have improved situational awareness, they did not seem to aid school security or mitigation of the shooter. In fact, there is evidence that the shooter benefitted from the PA notifications in completing their mission. As a result, **schools should consider developing a communications strategy/plan that allows for students, teachers, administrative staff, and an SRO** (or external law enforcement) **to effectively and efficiently share information** and updates with one another. Schools could also **consider investigating modern communications technologies** that could supplement such a strategy or policy.

SIMEX Takeaways

In addition to the findings and recommendations identified above, the following details the broader takeaways regarding the use of SIMEX as a tool to effectively evaluate school safety-related policies, technologies, and procedures:

- **SIMEX Assessment 1:** While SIMEX as a tool can provide valuable analysis and insights into the area of school safety, variables being examined need to be specific in scope, and constraints and assumptions need to be clearly outlined. Furthermore, when looking at an active shooter within a K-12 school scenario, SIMEX as a tool was found to be limited in flexibility and it does not always account for real-world factors that often influence incidents involving school security (i.e., behavioral and social cues exhibited by a shooter).
- **SIMEX Assessment 2:** Given the narrow scope of SIMEX as a tool when looking at an active shooter within a K-12 school scenario, findings are very context sensitive and as a result, associated recommendations need to account for the dynamic aspect of school operations and settings over the course of the school day.

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SECTION 1: INTRODUCTION

The Simulation Experiment (SIMEX) 20-6 After-Action Report is a summary of the School Security SIMEX, including the system development process, experiment design, timeline, and stakeholders. It provides a detailed analysis of the collected data, operator[3] responses, surveys, and observations and concludes with findings and recommendations.

The Department of Homeland Security's (DHS) Cybersecurity and Infrastructure Security Agency (CISA) sponsored SIMEX 20-6. George Mason University (GMU) partnered with DHS CISA and the MITRE technical team to provide research and data collection and analysis support from a human subject's research perspective. SIMEX student, teacher, and shooter operators were recruited from GMU student cadres. School resource officer (SRO) and school administrative official operators were professionals in their fields from local school districts.

1.1 Objectives

The objectives for SIMEX 20-6 included:

1. Examine and evolve school security policies
2. Develop concepts of operation (CONOPS) and tactics for school security operations
3. Examine current and proposed school security technologies and configurations

The designed experiment addressed these objectives while focusing on evaluating three key variables:

1. Whether a school resource officer is present and patrolling the school
2. Whether classroom doors are pre-locked or manually locked
3. Whether teachers can initiate the lockdown via a public address (PA) system notification or whether only the front office can initiate the lockdown via a PA notification

In addition to the formal experiment factors, the shooter operator was directed to execute a targeted shooting or a mass casualty attack during each run. This additional aspect was intended to capture a wider range of active shooter scenarios in a controlled manner.

1.2 Background

1.2.1 Simulation Experiments

Since 2001, MITRE's National Security Experimentation Laboratory (NSEL) and the Simulation, Experimentation, and Analytics Lab (SEAL) in McLean, Va. have hosted over 70 SIMEXs. During a SIMEX, observations and experiences of the participants are captured for reference and provided to doctrine, tactics, system, and application developers. Post-SIMEX analysis yields lessons learned, operator feedback, and data-driven measures of effectiveness, providing program managers, science and technology directors, warfighters, policy makers, and others the necessary information to make informed decisions by measuring against operational and technical performance criteria. SIMEX events last two weeks, including operator training and experiment execution, although the preparation process usually takes five to six months.

1.2.2 School Shootings in the United States

There have been over 1,500 shootings in U.S. schools since 1970 [1]. This number includes "each and every instance in which a gun is brandished, fired, or a bullet hits school property for any reason, regardless of the number of victims (including zero), time, day of the week, or reason" [2]. According to the School Shooting Database, perpetrators of such incidents are more often males that are currently students at the school. The most common incidents involve a handgun as the weapon type. Victims are most often individuals specifically targeted by the shooter and are students at the school [2]. In 2019 there were 114 incidents recorded that included a total of 24 killed and 88 wounded [2].

[3] This report uses the terms operator and participant interchangeably.

Following the deadly shootings at Marjory Stoneman Douglas High School in Parkland, Florida in February 2018, national leaders have called to make schools a "harder target" [3]. Suggestions include hiring more on-campus police, installing more metal detectors, and screening bookbags and handbags of students and visitors as they enter the school building. Due to the frequency and chaotic nature of school shootings as well as the diversity of school layouts, policies, and administration in the U.S., proposals to improve school security during active shooter events are difficult to evaluate.

1.2.3 Federal and Local Stakeholders

Federal stakeholders have instituted programs to address school security concerns. The Department of Education (ED) led the Federal Commission on School Safety established in March 2018, along with the Department of Health and Human Services (HHS), DHS, and the Department of Justice (DOJ). These agencies created SchoolSafety.gov as a platform for sharing actionable recommendations to keep school communities safe [4]. The DOJ and DHS have released educational materials on dealing with active shooters and the DOJ provides grants to state/local/tribal governments to improve school security.

Many states have initiatives focused on school safety with websites that offer training and planning resources including active shooter preparation. State initiatives of note include the Marjory Stoneman Douglas High School Public Safety Act in Florida, which created a new Office of School Security [5].

Broad stakeholder engagement in this critical public safety matter resulted in training best practices, school security policies, and some resourcing for infrastructure adjustments to mitigate the effects of school shooting events. Carefully designed experiments such as SIMEX 20-6 with their associated data-driven results, conclusions, and recommendations, can provide stakeholders with valuable insight not available through analysis of historical events.

1.2.4 SIMEX 20-6 Overview

SIMEXs historically are conducted as in-person events at MITRE's McLean campus. Due to travel and distancing restrictions imposed by the COVID-19 pandemic, SIMEX 20-6 was conducted as a distributed event at MITRE with experimental support provided from remote locations.

1.2.5 School Model

The SIMEX scenario was set in a virtual school environment modeled after designs used in current day schools and supporting 1,000 students. To accommodate the relatively small number of live participants in the experiment, just a section of the representative high school was modeled in the virtual environment using architectural best practices for school design. The school layout is found in Appendix A. The school model included classrooms, teacher breakrooms, utility rooms, bathrooms, a cafeteria, a library, and a front office. Outside the school was a sports field, parking lot, and the surrounding neighborhood. Hallways were colored to assist with navigation and familiarization: red, black, and blue hallways on the first floor and green, purple, and teal hallways on the second floor. The school has four entrances, one at each cardinal direction.

Ten of the classrooms were utilized as homerooms with human-operated teachers and students assigned to them as described in Section 2.7.2. The other classrooms remained closed and out of play.

1.2.5.1 Participants and Roles

The school was populated with 10 human-operated teachers and 20 human-operated students, as well as over 300 computer-generated artificial intelligence (AI) students to fill out the student body. A human-operated school administrator (also referred to as the admin throughout this document) handled communications through the front office. In several of the runs a human-operated armed SRO patrolled the school. See Section 2.7.1 for details on these roles.

The shooter was human-operated and assumed to be a regular student in the school familiar with the school's layout and procedures.

1.2.5.2 Scenario

The scenario begins in the morning 15 minutes before the first classes of the day. Students and teachers are milling about the school and making their way to their assigned classrooms. The SRO, if present in the scenario, patrols the hallways and interacts with students and teachers. The shooter enters the school as any other student, concealing a semi-automatic handgun and five spare magazines, each holding 15 rounds.

Once the shooter opens fire, teachers use available communications systems to notify the school of the threat, and the administrator in the front office issues a lockdown announcement. Teachers lock their doors while students evacuate, move into classrooms, or seek other ways to stay safe such as hiding in bathrooms.

The run continues until the shooter is neutralized, leaves the school, or one of the other end conditions is met. See Section 2.7 for details on the scenario design and implementation.

1.2.6 Participant Recruitment

The SIMEX included 38 participants from GMU, state and local school systems, and professional organizations for K-12 teachers. Table 1-1 lists the participants and their roles. All student operators were undergraduate students from GMU. For the role of active shooter, participants came from the GMU police cadet or criminal justice programs. For teachers, school administrative staff, and the SRO, relevant experience and/or current employment related to the role was required. All participants were screened for psychological and physiological fitness and were required to complete a preliminary assessment of COVID-19 symptoms and exposure risk, as delineated in Section 1.2.8. Individuals deemed at risk were removed from the recruitment pool. Due to the potential for participants to experience psychological and/or physiological discomfort, additional operators were recruited and trained for the student, teacher, active shooter, and SRO roles.

Table 1-1. Participants and Roles.

Role	Org.	Total Count	Per Run	Role Description/ Experience
Students	GMU	24	20	Participating students were undergraduate students from GMU. Students were distributed so there were two students per classroom.
Shooter	GMU	1	1	The active shooter was a GMU student enrolled in a law enforcement program. One active shooter.
Shooter (reserve)	GMU	1	0	A reserve shooter was a member of the GMU Police Cadet Program. SIMEX 20-6 did not utilize the reserve shooter.
Teacher	GMU Local school systems Professional organizations	11	10	Participating teachers were from professional organizations serving K-12 teachers or GMU with teaching experience and/or currently enrolled in a teacher certification program. Teachers were distributed so there was one classroom assigned to each teacher.
SRO	State and local school systems	2	1	The participating school resource officers were employed SROs from two state and local school systems. SROs were distributed in accordance with the run matrix, with no more than one SRO per run.
School Admin	State and local school system	1	1	The participating school administrator was an employed school administrator from a local school system. The school administrator was not in virtual reality but participated in each run.

1.2.7 Health and Safety

MITRE and GMU took numerous steps to protect the privacy and safety of all participants. Foremost was approval of all human subject research protocols by the GMU Institutional Review Board. Privacy was maintained using pseudonyms for all operators. Only the GMU research team and MITRE security staff were able to link participant pseudonyms to legal names.

To ensure psychological and physiological fitness, a three-phased screening protocol was implemented:

- **Phase 1:** Pre-screening questionnaire and psychological assessment
- **Phase 2:** Interview with licensed mental health professional
- **Phase 3:** Virtual reality suitability screening

Prospects were also screened for COVID-19 symptoms and exposure risk during recruitment selection and within 24 hours of SIMEX 20-6 execution. In Phases 1 and 2, only individuals who fell within standard ranges of adult functioning (e.g., no pathology or risk factors) were selected. In Phase 3, individuals were dismissed who were unable to tolerate VR.

To protect participants, all events were simulated and took place in a virtual environment, removing any possibility of physical harm. Student and teacher operators were not able to isolate or confront the shooter. While student and teacher operators were able to view the shooter's handgun, shots fired, and operators being shot, there was no animated blood or injury. As an additional precaution, the active shooter perceived students and teachers as "zombie-like" avatars.

During the SIMEX, operators were continuously monitored to ensure psychological and physiological safety using surveys, live observation by GMU and MITRE staff, and debriefings. Participant reports of distress were evaluated using the Subjective Units of Discomfort Scale (SUDS) in the pre-SIMEX, morning baseline, and post-run surveys as enumerated in Section 2.3.1.1. A daily COVID-19 health screening, with authorization to participate, was required for all participants.

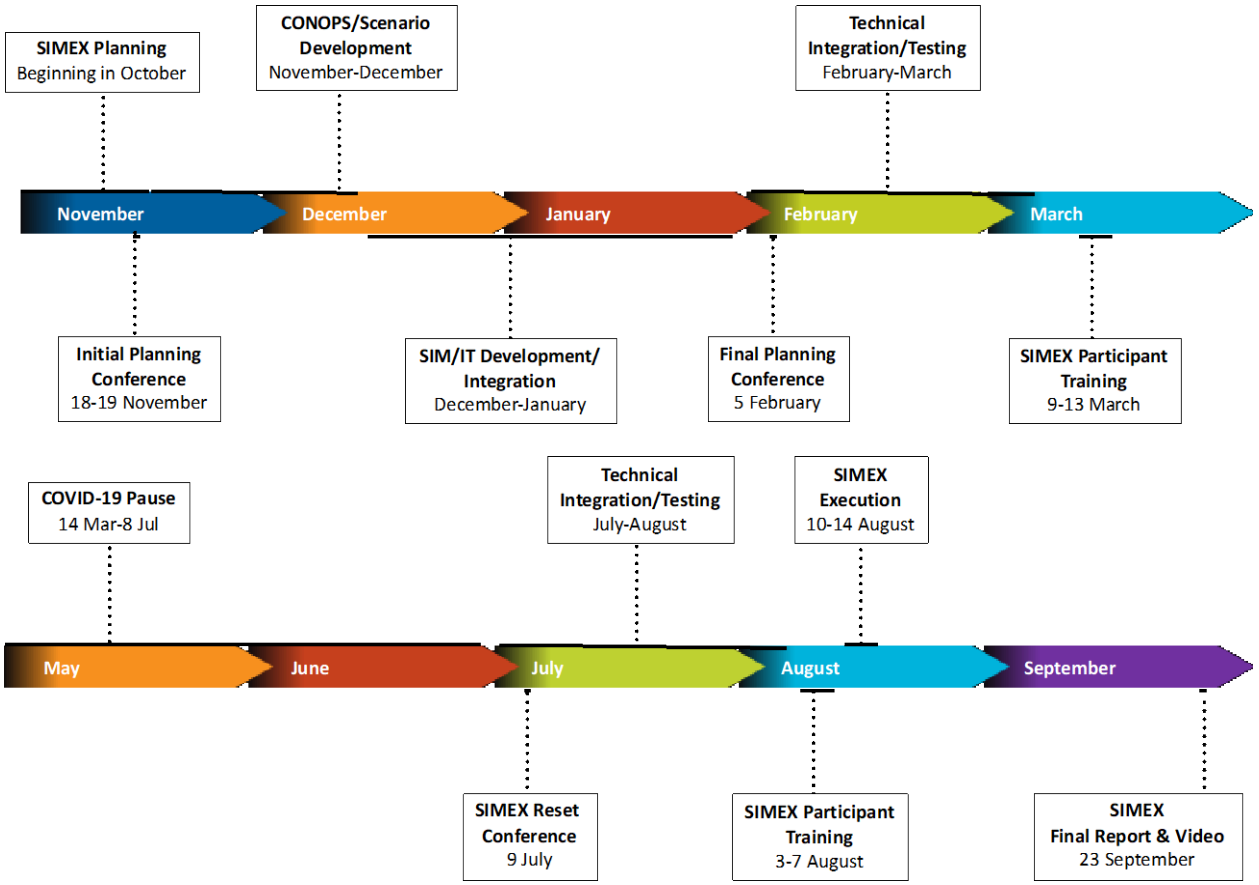
Protocols for reporting discomfort/distress, including acknowledgement that the SIMEX is a virtual, simulated environment, were reviewed at designated points throughout the experiment. Continuous observation of participants by GMU and MITRE staff served to mitigate response bias (minimized reports of discomfort/distress). Voluntary post-run and post-SIMEX debriefings allowed participants to reflect on what transpired during the run and how they felt about the experience. Both observation and operator debriefings were used to evaluate physical and emotional health. While crisis assessment and intervention protocols were established, they proved to be unnecessary. Two and four weeks after the SIMEX, a post-SIMEX psychological assessment was distributed to evaluate levels of traumatic stress.

1.2.8 Scheduling and Planning

The SIMEX Initial Planning Conference (IPC) was held November 18-19, 2019. School security experts from around the country attended in person, including representatives from seven state organizations, three counties, the National Association of School Resource Officers, the Partner Alliance for Safer Schools, and the American Institute of Architects. The experimental factors and design (see Section 2) were established in the IPC and documented in the SIMEX Data Collection and Analysis Plan delivered February 14, 2020. SIMEX preparations continued through early March culminating in execution of the operator training March 9-13, 2020. Immediately after the training week, DHS postponed SIMEX execution due to COVID-19 restrictions.

Work on the SIMEX resumed July 1, 2020, with development and testing of a safe and partially distributed environment to accommodate restrictions associated with COVID-19. Training began August 3, with experiment execution completed on August 14. Products included a video and this report delivered September 23, 2020. The overall schedule is depicted in Figure 1-1.

Figure 1-1. SIMEX Planning Timeline (November 2019-September 2020).



1.3 Report Organization

Section 2 provides information on the experimental design—the analysis focus, the use of design of experiments, descriptions of the metrics and of the factors under investigation, and an overview of the simulation systems employed. Section 3 presents the results, including statistical analysis of quantitative metrics and more general analysis and discussion of qualitative findings. Section 4 covers overall conclusions. Section 5 provides MITRE recommendations based on these findings.

SECTION 2: EXPERIMENT DESIGN

2.1 Analysis Focus

SIMEX 20-6 focused on understanding the impact of key factors in an active shooter situation at a high school. The relationship between these factors and outcomes was analyzed through formal statistical hypothesis testing. Relationships were also analyzed through exploratory data analysis and qualitative analysis of subjective survey data. Experimental runs produce data for metric derivation and analysis. SIMEX 20-6 used 24 experimental record runs and 10 additional wildcard runs to collect the data necessary to conduct the analysis for this report.[4] The following sections describe each analysis focus area in detail.

2.1.1 Analysis Focus 1: Confirmatory Data Analysis

Confirmatory Data Analysis (CDA) is used to evaluate evidence by challenging assumptions (hypotheses) about the data and relationships between data. CDA involves formal statistical processes such as hypothesis testing, regression, and analysis of variance. CISA program managers hypothesized that implementing automatically locking doors, allowing for centralized notifications, and the presence of an SRO would lead to better outcomes as measured by the metrics listed in Section 2.4. For SIMEX 20-6, hypothesis testing and other CDA methods were used to confirm whether the three experimental factors resulted in measurable, meaningful changes in performance.

2.1.2 Analysis Focus 2: Exploratory Data Analysis

Exploratory Data Analysis (EDA) is a collection of quantitative and visual methods used to characterize data, often by way of distributions and parameter estimation. EDA may uncover trends, patterns, and relationships between variables, and ultimately lead to new hypotheses to be tested in future experiments. Data from all record and wildcard runs were used to conduct exploratory analysis as were surveys and observer notes. Explicit and implicit themes and subthemes were identified within the post-run survey data that asked operators to briefly describe what happened during the run and if anything did not work as expected [6].

2.1.3 Analysis Focus 3: Technological, Procedural, and Operational Gap Analysis

Gap analysis describes the analysis activities used to develop feedback on perceived differences between current and future states. Surveys and facilitated hotwash sessions were the primary means by which such gaps were revealed.

2.2 Experiment Design

SIMEX 20-6 was designed as a full-factorial within-subjects experiment. Three experimental factors—presence of an SRO, door-locking policy, and lockdown notification policy—were chosen to measure the effects of school policies on the outcome of a school shooting scenario. Each factor had two conditions, yielding a 2x2x2 design.

A fourth independent variable—shooter mission—was introduced to assess whether the effects of the three factors vary based on the active shooter's goal. Each three-factor combination was replicated three times exploring two different shooter strategies (defined in Section 2.5). Figure 2-1 illustrates the factor design, with SRO presence on the vertical axis, lockdown notification policy on the horizontal axis, and door-locking policy on the depth axis. Each combination was replicated three times as shown by the dots at each corner of the cube: once with a "mass casualty" shooter goal and twice with a "targeted" shooter goal.

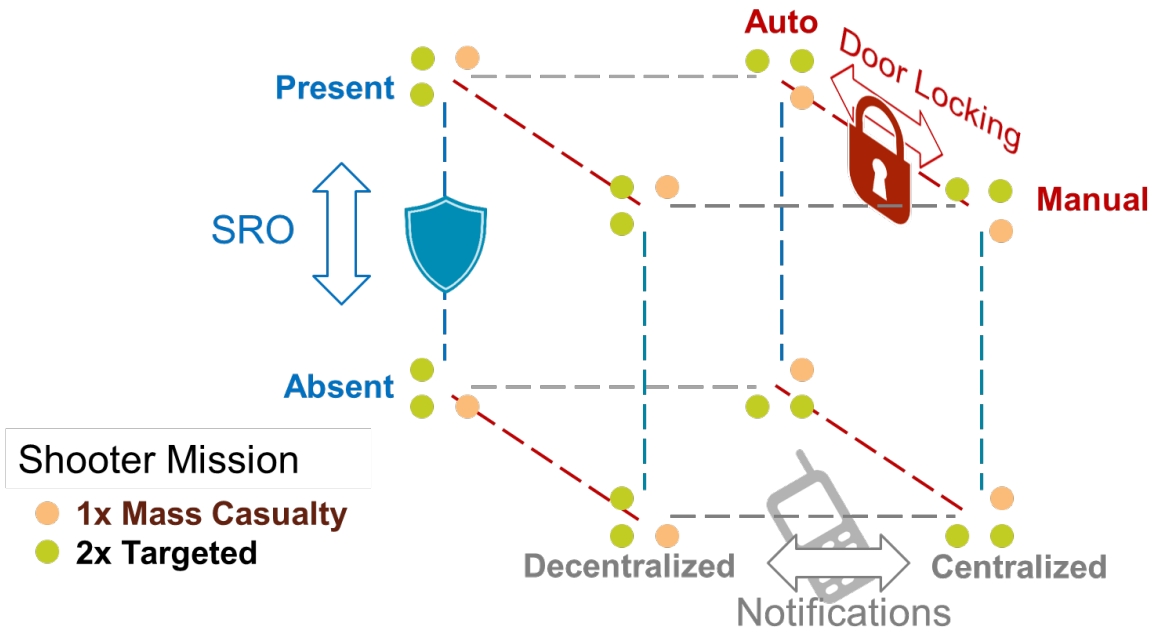
This experimental setup yielded eight factorial combinations replicated three times each for a total of 24 record runs. Additional runs, referred to as wildcard runs, were performed to break up the experiment, introduce variety, and examine additional concepts. The final run matrix showing the schedule of all 39 record and wildcard runs is found in Appendix C.[5]

A detailed description of each factor and its levels is in Section 2.5.

[4] Some record runs needed to be redone, yielding a total 39 runs.

[5] Some record runs were repeated due to technical issues, which inflated the total number of runs.

Figure 2-1. Illustration of Experimental Factors.



Randomization of runs in the design was used to ensure that any effects from the experimental factors were not biased by hidden effects, such as those associated with a learning curve or other temporal effects.[6]

2.3 Data Collection and Analysis Plan

2.3.1 Data Collection

Data was collected from multiple sources during the experiment including operator surveys, a manual web-based observation tool, and automated event logging in the simulation software.

2.3.1.1 Surveys

Surveys were completed by all SIMEX participants to gather subjective quantitative data on the participant experience as well as qualitative data on the experiment and the overall scenario.

SIMEX operators all completed a pre-SIMEX survey on the first day of training and a post-SIMEX survey on the final day of the experiment. All participants also completed a baseline screening survey every morning to gauge their psychological and physical status and a post-run survey to collect data on their experience during the run.

Several formal methods were used in the SIMEX surveys:

- SUDS survey questions were distributed to all participants in all surveys used to measure the participant's physical and emotional state during the experiment,
- The NASA Task Load Index (TLX) survey [7] was distributed to teachers, the admin, SROs, and the active shooter to assess the operator-perceived workload during the experiment runs.

[6] After randomization, runs were manually rearranged ad hoc for logistical reasons, including:
- To accommodate visitor briefings and production of video materials
- To keep participants engaged with wildcard runs each day
- To assign each of the two SROs an equal number of record runs
- To redo runs not completed successfully

- The Situational Awareness Rating Technique (SART) [8] survey was distributed to all operators in the post-run survey to gather information on the operator's perceived situational awareness (SA) during the experiment runs.

Additional questions in the pre- and post-SIMEX surveys asked participants about their perception of safety in schools and what factors were the most important in preventing the loss of life in active shooter situations in schools. The post-run survey also provided participants with simple selections to describe their experience during the run and all operators besides the students provided a free-response summary of the run.

2.3.1.2 Automatic Event Logging

The state of the simulation and events pertaining to the actions of the participants were automatically logged throughout all runs. Positional data for entities and data pertaining to shots being fired and casualties were also broadcast using the Distributed Interactive Simulation protocol and captured in real-time into a data collection database. All other events in the simulation—such as doors being locked—were logged by client/server systems controlling the VR environment. These logs were then parsed into the database following completion of the run, organized by the timestamp of each logged event.

2.3.1.3 Observations

During each run the shooter was observed by a member of the data collection team using the remote screen-sharing feature of Microsoft Teams and important behaviors were logged including the time the weapon was drawn and shots fired and the time the shooter left the school premises. The administrator was also observed and the time of the admin's lockdown announcement was logged. In addition to real-time observation, the perspectives of the shooter, admin, SRO, one teacher, and one student were recorded for later playback and confirmation of events.[7]

2.3.2 Data Analysis

The Analysis of Variance (ANOVA) method was applied to the quantitative metrics, all of which are continuous in nature (see Section 2.4). ANOVA is appropriate for testing for an effect of categorical factors on these metrics. ANOVA is based on the ratio of between-treatment variance to within-treatment variance. Where this ratio is sufficiently large, one can conclude that the treatment (of a factor) was significant.

As illustrated in Figure 2-1, a total of 24 record runs were executed, 16 runs with a targeted shooter mission and eight runs with a mass casualty shooter mission. For each metric, a first analysis was performed using eight mass casualty runs combined with eight of the targeted runs to form a full 2x2x2x2 matrix with equal representation of both types of shooter missions and one of every combination of factors. This first analysis with a balanced number of targeted and mass casualty missions made clear whether the metric differed significantly depending on shooter mission. After exploring the impact of the shooter mission on the metric, all 24 runs were used to investigate the effects of the three factors on the metric bringing all available data to bear.

Metrics linked to confirmatory data analysis (see Section 2.1.1) were tested for statistical significance. Exploratory data analysis was performed on all other metrics.

2.4 Metrics

SIMEX 20-6 metrics—or dependent variables—are measures of outcomes associated with the active school shooter event described in the SIMEX scenario. They were expected to be sensitive to the experimental factors under investigation. Whereas experimental factors (the independent variables) are controlled for each run and known beforehand as part of the experiment design, metrics (the dependent or response variables) are measured real-time, for each run, as an effect of that run's factor levels. The metrics are listed in Table 2-1.

[7] Due to limitations of the distributed technical setup, only video as seen by the operators and audio spoken by the operators (but *not* audio as heard by the operators) could be observed and recorded.

Table 2-1. SIMEX 20-6 Quantitative Metrics.

Metric	Description
Participant situational awareness	Broken out into participant type, measured using the SART technique in the post-run survey.
Participant workload (mental/physical/temporal demand, effort, and performance; self-rated)	Broken out into participant type (excluding students), measured using the NASA TLX technique in the post-run survey.
Stress/fear of participants	Broken out into participant type, measured using the SUDS technique in the post-run survey.
Physical harm to simulated participants	Casualties as a percentage of the total, including teachers, SRO, and both AI and player-operated students.
Percentage of "safe" students: evacuated or in lockdown at scenario end	Percentage of AI and player-operated students who are either outside the school or in a locked classroom when the scenario ends.
Time to lockdown announcement	Time from when the shooter draws his weapon to when the front office gives the lockdown announcement.
Time for classrooms to complete lockdown procedures	Time from when the shooter draws his weapon to when the final classroom closes and locks its door. Also takes into account what percentage of classrooms were successfully locked.
Time to end threat	Time from when the shooter draws his weapon to when the shooter is shot, surrenders, or leaves the premises.[8]

2.5 Factors

This SIMEX manipulated three experimental factors associated with school policies that hypothetically could affect the outcome of an active shooter scenario (see Table 2-2). These are: presence of an SRO, door-locking policy, and lockdown notification policy. The SIMEX examined two different settings or levels for each factor. To measure variance associated with experiment error, the design included three replicates of each of the eight factor combinations, resulting in 24 total record runs. In order to assess whether the effects of the three factors vary based on the active shooter's goal, two of these replicates were executed with a "targeted" shooter mission and one was executed with a "mass casualty" shooter mission.[9]

Table 2-2. Overview of Factors.

Factor	Levels	Description
Presence of SRO	SRO Present	The SRO was in the school roaming the hallways.
	SRO Absent	There was no SRO in the school.
Classroom Door-Locking Policy	Doors Already Locked	When closed, classroom doors were automatically locked.
	Manual Locking	Teachers had to lock classroom doors when closing them.
Lockdown Notification Policy	Centralized Communications	Teachers called the front office to provide notification and updates. The administrator used the PA to notify the school and give the lockdown announcement.

[8] This metric was originally defined as time to when the active shooter was shot/subdued. Because this happened in one record run (34), it has been redefined to include all scenario end conditions: the shooter leaving the school and the timeout condition.

[9] This two-to-one ratio was based on the statistic that nearly three quarters of all school shootings are planned with a specific person as a target. [3]

Factor	Levels	Description
	Decentralized Communications	Teachers could use the PA system to notify the school of lockdown initiation and updates. The administrator gave the official lockdown announcement.
Shooter Mission	Targeted	The shooter was assigned a particular individual to target.
	Mass Casualty	The shooter was directed to target as many people as possible.

2.5.1 Factor 1: Presence of SRO

It was assumed that all teachers and students (including the shooter) knew whether an SRO was assigned to the school. All participants were told before a run whether the SRO would be present or not.[10] The SRO had a distinctive avatar recognizable to all participants and was the only participant virtually armed and authorized to neutralize the threat. If present, the SRO was directed to act based on training and experience to patrol and protect the school. Runs without an SRO represented a situation in which either a school has no SRO, or the SRO is elsewhere (e.g., directing traffic).

Because the SRO is the only role with the ability to directly confront the shooter, it is expected that the presence of an SRO in the school acts as a mitigation and/or deterrence and will improve the outcome of an active shooter event.

Hypothesis One: The presence of an SRO will reduce casualties and increase the number of students evacuated or in lockdown during an active school shooter event.

2.5.2 Factor 2: Classroom Door-Locking Policy

All classroom doors were equipped with locking mechanisms on the hall-facing side. In runs with doors already locked, the doors would lock automatically when closed, emulating a school with auto-locking mechanisms or a school in which teachers were directed to keep their doors locked at all times. (This report refers to this state as automatically locking, pre-locked, or already locked.) In runs with manual locks, teachers had to virtually reach out and press the locking mechanism for a duration that varied randomly between 3 and 6 seconds to activate the lock (see Figure 2-2). Teachers did not know when they started the locking process exactly how long it would take to complete. The manual lock would not engage if the locking process was interrupted during this time. This randomized duration was determined at the initial planning conference and follow-up discussions and is meant to approximate the time needed to manipulate a keychain and key lock or to input a numerical code on a keypad.

Because manual locks require teachers to perform an extra step when closing and locking their doors, it is expected that pre-locked or automatically locked doors will allow faster lockdown and improve the outcome of an active shooter event.

Hypothesis Two: Doors that are already locked will reduce casualties and increase the number of students evacuated or in lockdown during an active school shooter event.

[10] The SIMEX did not capture the case of an SRO with a schedule unknown to teachers and students.

Figure 2-2. Teacher Engaging the Door-locking Mechanism.

2.5.3 Factor 3: Lockdown Notification Policy

Each teacher avatar was able to activate communications using buttons on the physical hand controller. In runs with centralized communications the teachers were directed to use the A button on the controller to contact the administrator directly, emulating a direct phone line to the front office. In runs with decentralized communications the teachers were directed to use the B button on the controller to broadcast through the PA system.

Because centralized lockdown notification requires that all information pass through the front office, it is expected that decentralized notifications will allow teachers, students, and the SRO to respond more promptly to emerging threats and improve the outcome of an active shooter event.

Hypothesis Three: Decentralized lockdown notifications will reduce casualties and increase the number of students evacuated or in lockdown during an active school shooter event.

2.5.4 Replication Variable: Shooter Mission

The shooter mission was manipulated to determine whether the three factors yielded different outcomes depending on the type of shooting event. In a targeted mission, the shooter was directed to eliminate the teacher in a particular classroom. In a mass casualty mission, the shooter was directed to eliminate as many people as possible. Exact directions are described in the run methodology (Section 2.8.4).

This variable was included for exploratory analysis and has no associated hypotheses.

2.6 Limitations and Considerations

As a low-risk virtual reality approximation of an active shooter event, this experiment has several important differences from a real-life event that could affect outcomes. For instance, implementations of door locks, communications, and other dynamics in the environment were not exact replicas of real-life counterparts.

This simulation is intended to determine the effects of the factors on just an active shooter event. It is not meant to evaluate the factors in relation to any other event and cannot predict their long-term effect over many typical school days. For example, a policy of keeping classroom doors locked at all times may have a long-term effect on teacher attitudes over time that is not captured by this experiment.

2.6.1 Participant Expectations

In this experiment, participants were expecting an active shooter and may have reacted more quickly than students and teachers would react in a real active shooter situation. Teachers had to be instructed not to lock their doors until they became aware of a threat. Any gunshot noise in proximity prompted participants to begin emergency procedures.

Wildcard runs, some of which were meant specifically to defeat participants' expectations, were distributed in between record runs as described in Section 2.8.2. (these runs were not used for data collection).

2.6.2 SRO and Shooter Dynamics

As noted in Section 2.7.2, the SRO was assigned an initial location dependent on the shooter's target to control the distance between the SRO and shooter across runs. However, the SRO's movements were not tightly controlled and from the initial location the SRO patrolled the school according to his own discretion. This means that when the threat was announced, in some runs the SRO may have been far from the shooter and in other runs closer. The SRO's location when alerted to the threat does affect the time needed for the SRO to move to the shooter and therefore could impact experimental outcomes. However, the SRO's position could not be controlled more precisely without artificially scripting the role, effectively removing the human element from the experiment.

2.6.3 SRO Operator Characteristics

Across the experiment days two different SRO operators switched off between runs (with an equal number of record runs assigned to each operator). It is possible that individual differences in behavioral styles among these participants may have affected the run outcomes. The randomization of run order and alternation of SRO operators was intended to mitigate this effect.

2.7 Scenario

The scenario is designed to reflect a typical school day and highlight the experiment factors discussed in Section 2.5. The scenario takes place at the beginning of the school day at 7:45 a.m. During this time students are typically entering the school and performing last-minute activities before class. Teachers are on their way to their homerooms or already waiting for students. The administrative office is handling visitor requests and calls. An active shooter can potentially take advantage of the business and confusion of the school morning.

2.7.1 Roles

The execution of the SIMEX depended on participants playing a variety of roles to enact an active school shooter scenario. Details on participant recruitment are in Section 1.2.6. Table 2-3 summarizes the activities of each role during the scenario.

Non-shooter participants were encouraged to approach each simulation run as if it were a normal school day and to react to circumstances in consonance with how they imagined they would react in a similar real-life situation. Pursuant to maintaining this realism, the technical team intentionally did not brief non-shooter participants on the particulars of the shooter's mission during the run (targeted versus mass casualty) or run-ending conditions (see Section 2.8.4.5). Other aspects not briefed to non-shooter participants included the factors under investigation in the SIMEX (see Section 2.5) or measured metrics (see Section 2.4).

Table 2-3. Scenario Overview by Role.

Role	Actions Before Threat	Actions After Threat
Student	Follow mission: Go to location X, then Y, then homeroom.	Evacuate, move to a homeroom, or find concealment.
Teacher	Start at assigned starting location (which could be the homeroom). Move to homeroom if needed.	Notify the front office or use the PA. Usher students into homeroom. Lock and close door.
SRO	Start at assigned starting location. Perform patrol duties.	Protect the school. Move to the threat. Take appropriate action.
Administrator	No particular guidance.	Issue lockdown announcement. Receive and issue updates. Stay in contact with the SRO.
Shooter	Move to assigned room; locate target if targeted mission.	For mass casualty mission, shoot as many people as possible. For targeted mission, no guidance once target is killed.

2.7.1.1 Students

Twenty participants played the role of students in the school. These operators were tasked with moving through the school to assigned homerooms as described in Section 2.7.2. In response to a threat, students were instructed to evacuate, move to a classroom with a teacher, or find other concealment. In addition, each run was populated with 301 AI-enabled computer-generated students, referred to as non-player character (NPC) students. These NPC students moved through the school hallways and classrooms and in response to a threat attempted to move outside or crouched in place.

2.7.1.2 Teachers

Ten participants played the role of teachers in the school. These operators were tasked with moving to assigned classrooms, greeting students, and protecting students by closing and locking classroom doors during a threat. In addition, teachers were responsible for communicating information about the active shooter using either a direct line to the front office or the PA system.

2.7.1.3 Administrator

One participant played the role of an administrator in the front office. This operator was responsible for announcing the lockdown over the school's PA system and communicating with the teachers and SRO during a threat.

2.7.1.4 School Resource Officer

Two participants alternately played the role of an SRO for the runs in which an SRO was present in the school. One operator attended on days one, three, and four of the experiment. The other attended on days two, five, and six. Both operators attended on day seven. These operators relied on their training and experience as real-life SROs to patrol and protect the school and to pursue the shooter.

2.7.1.5 Active Shooter

One participant played the role of the active shooter. This operator was located in a separate room by himself.[11] The shooter operator was tasked with attempting either a targeted or mass casualty shooting as described in Section 2.8.4 and explored strategies during the run to avoid being detected and stopped.

2.7.2 Homerooms, Starting Locations, and Student Missions

At the scenario start operators were instructed to perform actions that model a school morning as enumerated in Table 2-3. Ten of the classrooms were designated homerooms (see Appendix A for school layout with marked homerooms). Each teacher was assigned to a homeroom, one teacher per classroom. Two human-operated students were also assigned to each one of these homerooms.

Human-operated students appeared outside the school at the main entrance while NPC students populated inside the school by moving through the halls and rooms. Each student participant had a handout with missions A-J, varying by student. A student mission consisted of three locations to visit: two locations around the school, such as a specific hallway and a bathroom or library, followed by the student's homeroom. Students commenced their missions at the scenario start. A sample student mission handout is in Appendix D.

Teachers appeared outside the school at the main entrance and were asked to move to other locations before scenario start, which could either be the homeroom or a different location such as a teacher break room. Each teacher had a handout with starting locations A-J, varying by teacher. The starting location was indicated in the pre-run briefing. A sample teacher starting locations handout is in Appendix E. Upon scenario start, teachers were directed to move to their homerooms if not already there.

In runs with an SRO, the SRO's starting location was configured based on the shooter's homeroom to control the distance between the SRO and shooter across runs. The SRO was notified of the starting location during the pre-run briefing and selected the assigned location from a menu when starting the VR environment. The SRO could be assigned any of the following starting locations:

[11] The active shooter operator was male, in line with the statistic that 83 percent of school shooters are male. [9]

- Main entrance
- Sports field (rear) entrance
- East entrance
- West entrance
- Cafeteria

2.7.3 Timeline

As implemented in the SIMEX, teachers are either already at their homerooms or are moving to their homerooms, and students are walking around the school performing their missions. The SRO, if present in the scenario (Factor 1), patrols the hallways and interacts with students and teachers. The shooter enters the school as any other student, concealing a semi-automatic handgun and five spare magazines, each holding 15 rounds.

Once the shooter opens fire, teachers either use the PA system to notify the school of the threat or the radio to notify the front office depending on the lockdown notification policy (Factor 3). No matter how the initial notification is made, the administrator in the front office issues a lockdown announcement over the PA. Teachers lock their doors if manual locking is required (Factor 2) while students evacuate, move into classrooms, or seek other ways to stay safe such as hiding in bathrooms.

The run continues until the shooter is neutralized, leaves the school, or one of the other end conditions is met (Section 2.7.4). An example timeline of important events is in Table 2-4.

Table 2-4. Example Timeline of Key Events During a Scenario (Run 14).

Event	Minutes; Seconds
Shooter enters school	1:22
Shooter draws weapon	2:38
First shots fired	2:38
Front office announces lockdown	3:06
SRO killed	3:56
Last shots fired	4:15
Last homeroom enters lockdown	4:29
Shooter leaves school	4:38

2.7.4 Lockdown Procedure

The lockdown procedure was derived from guidance received at the Initial Planning Conference and follow-up conversations with school security personnel, as well as emergency response materials from federal organizations and nine different states. This document uses the following terms when describing lockdown initiation and execution:

- Notification of a shooter: this is when the first teacher (or SRO) notifies the front office by radio or broadcasts via the PA system that there is a shooter.
- Lockdown notification: this is when the lockdown is announced to the school via the PA system by the front office (even if a previous announcement was made by a teacher).
- Lockdown procedures: these are the steps staff, SRO, teachers, and students take once they know a lockdown is in effect.

The lockdown procedure changed depending on the scenario run and the experimental factors. The instructions below are written as they were given to the participants, in the present or imperative tense.

1. Notification of a shooter:
   a. With centralized notification (Factor 3), teachers must notify (Figure 2-3) the front office of the school shooter situation. Each teacher has a radio emulating a direct phone line to the front office.

Figure 2-3. Recommended Teacher Lockdown Notification From the Teacher Handout Materials.

> This is Teacher X.
> There is an Active Shooter in Location Y.
> We are entering a lockdown.

   b. With decentralized notification (Factor 3), teachers use an emulated radio on their person (activated via button press on the VR hand controller), representing a wearable device in use by some schools, to make the initial announcement on the PA system.
   c. If the SRO learns of the shooter before any teacher, the SRO should notify the front office via radio.
2. Front office/administration staff notification process:
   a. Make the official lockdown notification (see Figure 2-4) through the PA system.

   Note: While teachers can initiate the announcement in the case of decentralized notifications, the full lockdown announcement must be completed by the front office.

Figure 2-4. Recommended Front Office Lockdown Notification From the Administrator Handout Materials.

> This is Staff X in the Front Office.
> There is an Active Shooter in Location Y.
> We are entering a lockdown.
> At this time, secure students in your classrooms and take attendance.
> Students, report directly to the nearest room with a staff member.
> No one should enter the building.
> Ignore bells and fire alarms unless smoke or fire is visible.

   b. Notify the SRO of the situation using the radio, if the SRO is present in the school (Factor 1).
   c. Receive calls from the teachers and record updates on shooter.
   d. Notify the SRO of any updates.
3. Teacher actions:[12]
   a. Usher students into their classroom.
   b. Lock the door, go into classroom, shut the door.
   c. Note: with auto-locking doors, the teachers do not have to lock the door and the teachers and students have the ability to go into the nearest classroom (Factor 2).
   d. Cover the window of the classroom door.

Note: This happens automatically in the simulation.

4. Students actions include proceeding to the safest hiding location in the following order of preference:
   a. Nearest classroom with a teacher
   b. Leave the building
   c. Other concealed location such as a bathroom

[12] Some emergency response materials direct teachers to report a head count to the front office. Teachers sometimes did this during the SIMEX runs. However, it is understood that roll call would typically be postponed until after the threat has ended to minimize noise during lockdown.

5. SRO actions:
    a. Receive call from front office
    b. Move through the school to find the shooter
    c. Observe the individual, decide next steps
    d. Take any action necessary
    e. Keep the front office informed via radio[13]

Students and teachers also have the option to evacuate the building as they see fit.

2.7.5 Scenario End Criteria

The scenario ends when one of the following is satisfied:

- The shooter is killed
- The shooter surrenders by dropping his gun and putting his hands in the air
- The shooter leaves the school premises
- Seven minutes elapse[14]

2.7.6 Other Rules of Engagement

Teachers and students were directed not to engage with an active shooter and were not able to block or harm the shooter in any way.

The active shooter was directed not to attempt to enter or shoot into locked classrooms.

2.8 Experiment Execution

SIMEX 20-6 execution was conducted from August 3-14, 2020. During the first three days, as shown in Table 2-5, operators were introduced to the SIMEX and trained in the operation of the equipment and software. By the end of the first week, operators performed their operational roles and stabilized the procedures and rules of behavior that would apply for the remainder of the experiment. Record runs began on Thursday and Friday of the first week.

Table 2-5. Training Schedule.

Day	Date	Time	Activity
Monday	August 3	a.m.	Orientation; security
Monday	August 3	p.m.	System login; system familiarization including VR
Tuesday	August 4	a.m.	Roles and lockdown procedures training
Tuesday	August 4	p.m.	Simulation practice and system testing
Wednesday	August 5	a.m.	Simulation practice; TTP review
Wednesday	August 5	p.m.	Simulation practice; TTP finalization

The execution week consisted of record runs that were needed for the design matrix and wildcard runs for additional exploration. Six runs were scheduled each day—three in the morning and three in the afternoon. A seventh run was added on Thursday, August 13. Three runs were executed the morning of Friday, August 14, followed by an after-action review brief for the participants. A typical daily schedule is in Appendix F.

- Activities for each run included:
- Simulation setup and initiation

[13] During a real-life emergency, the SRO is likely to be in frequent contact with dispatch rather than the school office. Due to the focus on intra-school security measures, the SIMEX depicted only contact between the SRO, the front office, teachers, and students.

[14] This is derived from real times for law enforcement to arrive at school shooting events nationally. [9]

- Operator roll call, run briefing, login, and screen share
- Run start (STARTEX), conduct, and end (ENDEX)
- Operator survey completion
- Post-run discussion and debriefing (hotwash)

Operators also submitted end-of-day and end-of-SIMEX surveys.

The SIMEX 20-6 run matrix, shown in Appendix C lists each run in the design matrix, and additional wildcard runs, in the order executed. The run order as executed reflects the randomization required to manage nuisance factors that have a temporal component.

2.8.1 Record Runs

Record run scenarios were designed to provide data collection opportunities to explore the effects of experimental factors on the outcomes of an active shooter event. Data collection during the record runs supported calculation of the metrics outlined in Section 2.4.

2.8.2 Wildcard Runs

Wildcard runs were designed to facilitate exploration of topics not addressed through the record runs. Wildcard runs were also used to introduce variety and unpredictability to the experiment, since repetition within the experiment can lead to unintended learning effects.

The time slots allocated for wildcard runs were extra runs of lower priority than the record runs; where one or more record runs were invalid due to technical problems or other issues, wildcard run slots were re-allocated as makeup runs to complete the run matrix.

The wildcard runs addressed premises such as:

- There is no active shooter (normal day)
- There is gunshot noise but no other evidence of a shooter
- The shooter[15] draws his weapon in class but does not use it unless threatened
- The shooter removes hostages from the school but does not discharge his weapon
- A bomb threat is called in to the front office (no shooting)

2.8.3 SIMEX Execution Staff Responsibilities

Though many staff were essential to executing the SIMEX, those roles that were integral to the experimental methodology are described below.

2.8.3.1 Coordinators

Two SIMEX staff served as coordinators, one for the shooter and one for the rest of the school. The coordinators communicated with the participants remotely using Microsoft Teams and were responsible for giving the pre-run briefings and facilitating the post-run hotwashes, as well as walking participants through the setup, start, and end processes for each run.

2.8.3.2 Room Monitors

A room monitor was stationed in each room with participants, except the room with the shooter, which due to COVID-19 restrictions could only support one occupant. The room monitors were responsible for in-person interactions with the participants, repeating the coordinators' instructions when necessary, answering questions, and identifying technical issues. The room monitors also assisted with the small group hotwashes described in Section 2.8.4.5.

2.8.3.3 Observers

Two SIMEX staff served as dedicated observers: one for the shooter and one for the administrator. The observers used Microsoft Teams screen-sharing features to monitor the simulation as seen by the shooter and administrator. The shooter observer reported the times of key events so that the team could track ending

[15] Even though the shooter operator did not discharge the weapon during these runs, the term shooter is still used for consistency.

conditions such as the shooter leaving the school premises. The administrator observer noted the lockdown announcement time for data collection and reported any issues with teacher and SRO communications to technical support.

2.8.3.4 Technical Support

Multiple staff served as technical support to help address issues with network connectivity and VR controls among the participants.

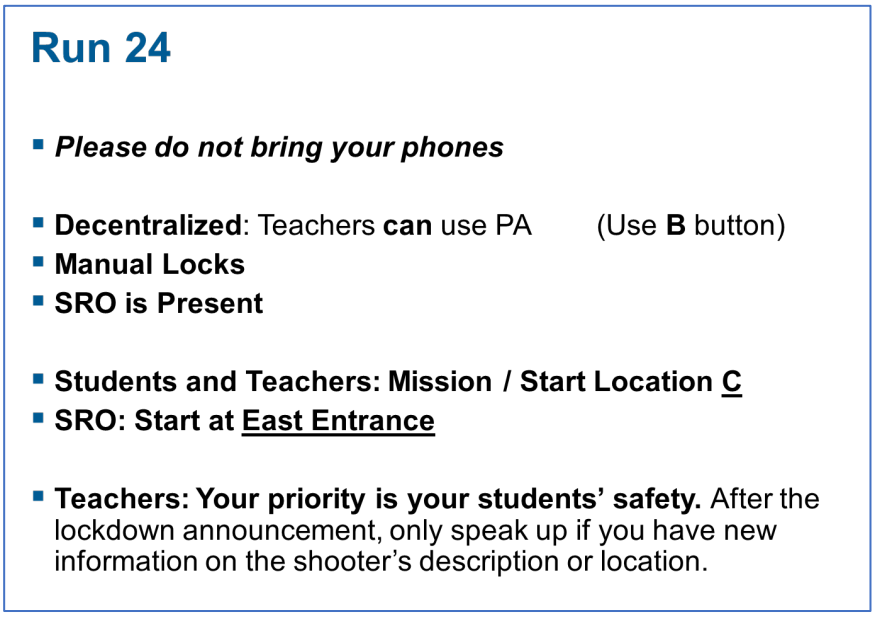
2.8.4 Run Methodology

2.8.4.1 Non-Shooter Participant Brief

At the beginning of a run participants were briefed on relevant configuration parameters with a visual slide and voice announcement. Students, teachers, the admin, and the SRO were shown a briefing slide (see Figure 2-5) with the following information:

- Whether the SRO is present (Factor 1). As mentioned previously, the SIMEX scenario models a school in which the students and teachers know whether to expect an SRO.
- Whether classroom doors have manual or automatic locks (Factor 2).
- Whether teachers can use the PA for decentralized notifications (Factor 3).
- A letter A-J referring to an entry on the student mission and teacher start location handouts.
- If present, the SRO's starting location.
- Other reminders.

Figure 2-5. A Non-Shooter Briefing Slide.

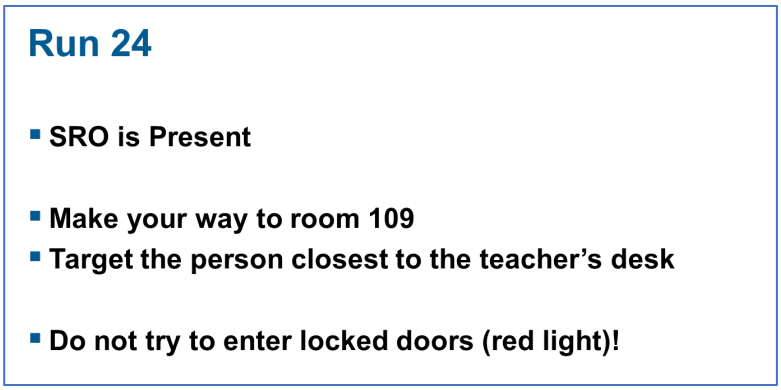


2.8.4.2 Active Shooter Brief

The active shooter, in a separate room, received a briefing slide (see Figure 2-6) with the following information:

- Whether the SRO is present (Factor 1). Since the shooter was a student in the SIMEX scenario it was assumed he would know whether the school had an SRO, like any other student.
- A classroom number to visit (presumed to be the active shooter's regular homeroom).
- Whether to attempt a targeted or mass casualty shooting. In the case of a targeted mission he was directed to target the person "closest to the teacher's desk" because the active shooter perceived all characters as zombies (see Appendix I) and had difficulty distinguishing teachers from students.
- Other reminders.

Figure 2-6. An Active Shooter Briefing Slide.



In the case of a wildcard run, the non-shooter briefing appeared as normal with all expected parameters so that the wildcard event would come as a surprise to the students, teachers, administrator, and SRO. The shooter briefing, on the other hand, gave specific instructions pertaining to the wildcard event such as taking hostages or refraining from shooting.

2.8.4.3 Run Setup

Operators were asked to put on their VR headsets and start the VR environment. At this time, any participant encountering technical issues could receive technical support. Teachers and the SRO, if present, moved to assigned starting locations as briefed. Also at this time, the administrator confirmed communications with each teacher and the SRO in turn to identify and mitigate any technical issues with operators' audio communications.

2.8.4.4 Run Execution

STARTEX was called simultaneously for all participants to commence the scenario. Teachers, if their starting location was not their homeroom, moved to their homerooms. Students exercised their missions from their handouts as briefed, visiting various locations in the school before arriving at their homerooms. The active shooter moved toward the assigned homeroom and waited for any assigned target. Once shots were fired each participant acted according to the guidance provided by the lockdown procedure (see Section 2.7.4) and individual discretion.

2.8.4.5 Run End

When one of the scenario end conditions was satisfied (see Section 2.7.5), ENDEX was called simultaneously for all participants. Each operator filled out the post-run survey for the run. Operators then shared experiences and thoughts from the run during a facilitated hotwash, with one hotwash for teachers, students, the SRO, and the administrator and a separate hotwash for the shooter operator in a separate room.

For the non-shooter participants, since they were distributed among multiple rooms, room monitors oversaw separate hotwash sessions in each room for five to ten minutes. Following this, SIMEX staff facilitated a unified hotwash through Microsoft Teams in which room representatives (participants) provided a synopsis of each room's observations of the preceding run. These unified hotwashes were recorded for qualitative data analysis.

2.8.5 Populations Per Run

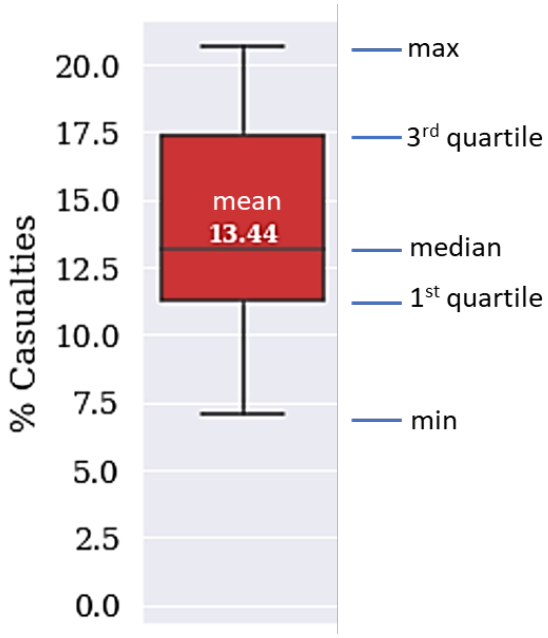
As noted in Section 2.7.1, the scenario was designed to accommodate 10 human-operated teachers and 20 human-operated students. Due to the SIMEX being distributed across multiple rooms (see Appendix I) and the incidence of connectivity issues, the actual number of participants varied from run to run. To account for these slight variances, any metrics related to teachers and students were taken as percentages of the total numbers of teachers and students in the run.

SECTION 3: RESULTS AND FINDINGS

Data was analyzed according to the data collection and analysis plan described in Section 2.3. An overview of data inputs to the analysis is in Appendix G.

Statistical results in this report are shown as boxplot graphs. See Figure 3-1 for an explanation of how to read each boxplot. The top whisker marks the maximum value across all runs and the bottom whisker marks the minimum value across all runs. The middle line marks the median. The white number is the mean and is positioned at the mean. The box is drawn between the first and third quartiles, meaning that 50 percent of all data points fall within the box: 25 percent between the top whisker and the top of the box, 25 percent between the top of the box and the median, 25 percent between the median and the bottom of the box, 25 percent between the bottom of the box and the bottom whisker.

Figure 3-1. Explanation of Boxplots in This Report.



3.1 Presence of SRO

The SRO when present in the school was found to significantly reduce casualties and improve student safety. As mentioned in sections 2.5.1 and 2.8.4, all participants including the shooter knew whether the SRO was present in the school each run. This SIMEX did not capture the case of an SRO with an unpredictable or unknown schedule.

3.1.1 Impact on the Scenario Timeline

Important events occurring throughout the scenario can be plotted together as a timeline (see Figure 3-2 and Figure 3-3). While not significant when considered separately, there were effects to the onset and duration of events that are notable when viewed together.

When there was an SRO, the onset of shooting occurred earlier in the run (median first shots 2.7 versus 4.6; mean 3.5 minutes versus 4.2 minutes). Most of the shooting and deaths in these runs occurred in the first five minutes after start, while more deaths when the SRO was absent occurred between five and eight minutes.

When the SRO was present, the shooter felt time pressure and had a sense of urgency to accomplish the mission. In runs without an SRO, the shooter was more relaxed and took more liberties. In the description of his strategy during a non-SRO run, the shooter stated, "Since there was no SRO… I had nothing else to worry about," indicating a more relaxed approach when no SRO was present. In another debrief, the shooter stated that there had been "no SRO for so many runs, it's giving me an 'I can do what I want mentality' without having to keep looking over my shoulder."

Figure 3-2. Timeline of Important Scenario Events Across All Runs Broken Down by SRO Presence.

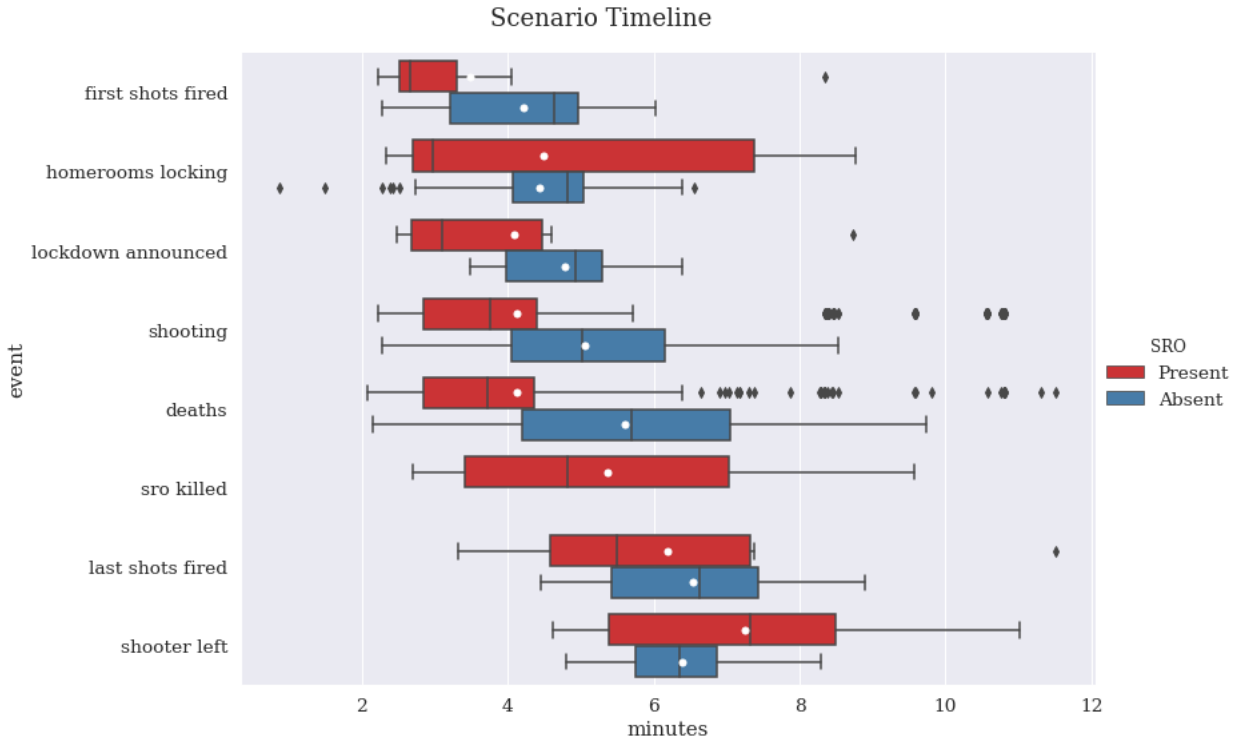
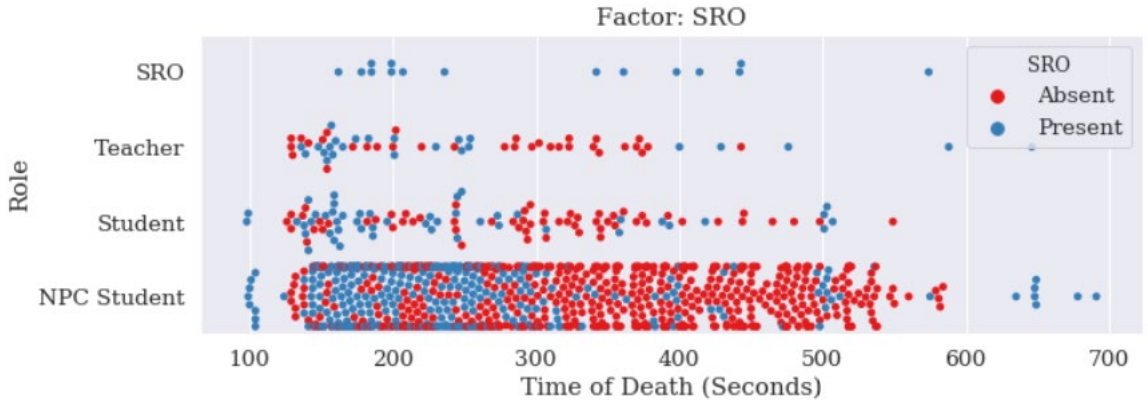


Figure 3-3. Swarm Plot Showing Casualties Over Time Across All Runs Broken Down by SRO Presence.



3.1.2 Casualty Percentages

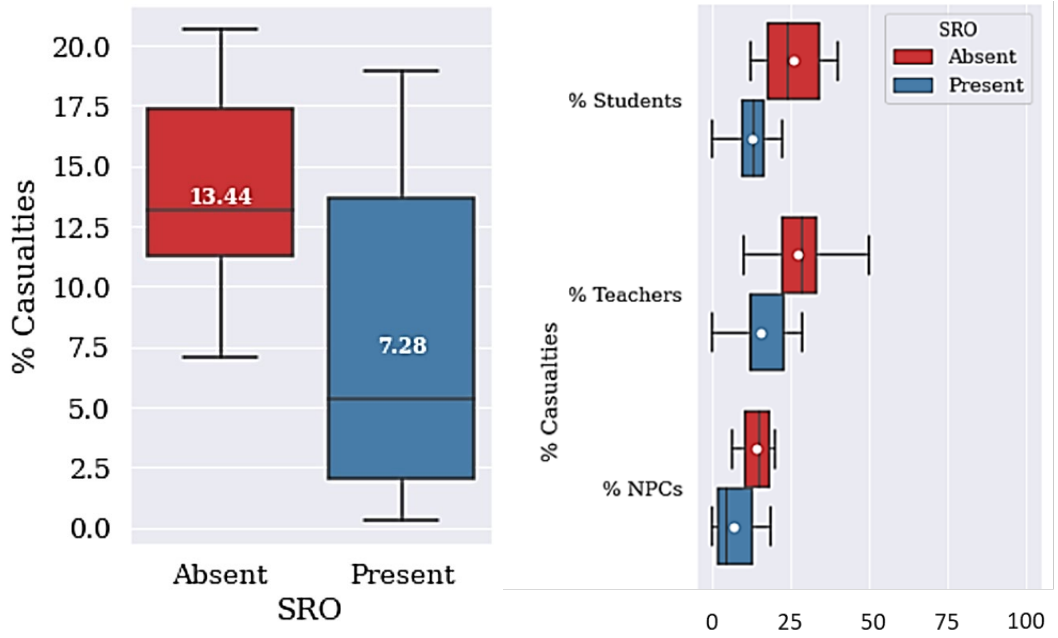
Casualties as a percentage of total population (human-operated students, AI students, teachers) was significantly lower when the SRO was present (median 5 percent of total population killed versus 13 percent; mean 7 percent versus 13 percent; p=.022[16]) as shown in Figure 3-4. The SRO's presence significantly lowered percent casualties for human-operated students, NPC students, and teachers, whether considered as separate groups or as a whole. Post-run survey responses included numerous reports from teachers highlighting that the presence of the SRO saved their life or made them feel safe:

- "The SRO came in, tried to diffuse the situation and I survived."
- "[The SRO] checked up on us and we responded that we're all safe and ok for now."
- "[The SRO] talked to us twice to make sure we were safe."

In other post-run survey comments, teachers reported feeling unsafe without the SRO:

- "Without the SRO, we are literally 'sitting ducks,' just waiting to get shot, there is not much I can do to save my students if the shooter wants to kill us."

Figure 3-4. Percent Casualties Across All Runs Broken Down by SRO Presence with Students, Teachers, and NPCs Together (left) and Separated (right).



3.1.2.1 Related Metric: Shots Fired

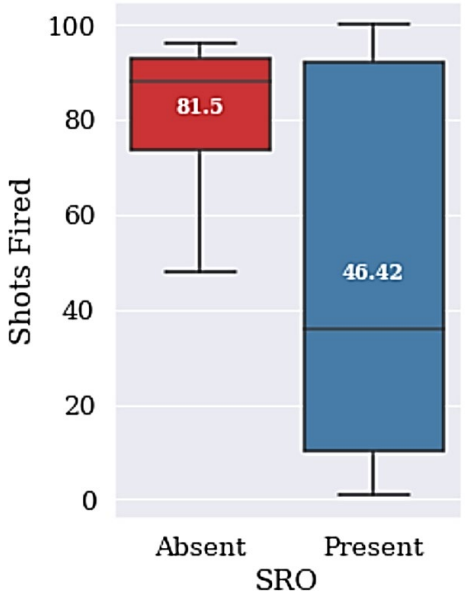
Total shots fired per run (out of 90) was analyzed for further insights on casualties. The effect was significant When the SRO was absent, the shooter tended to discharge nearly all available ammunition. (median 88 shots fired versus 36; mean 81.5 versus 46.42; p=.016). In most runs (70.5 percent) with the SRO absent, the shooter's post-run survey feedback mentioned intentionally discharging all ammunition before the run ended:

- "I killed everyone in the room and then sat down and waited for the run to end."
- "I just wandered looking for all of the known hiding spots that I knew I could get to. I ran out of ammunition in the cafeteria and left."

When the SRO was present, the number of shots fired by the shooter varied across the entire range with a mean value in the middle of the range (see Figure 3-5). These results may be explained by the shooter's focus on neutralizing the SRO and his intent to save ammunition in the event of a confrontation.

[16] The *p* value is an indicator of statistical significance. In this report a *p* value of less than .05 is considered significant.

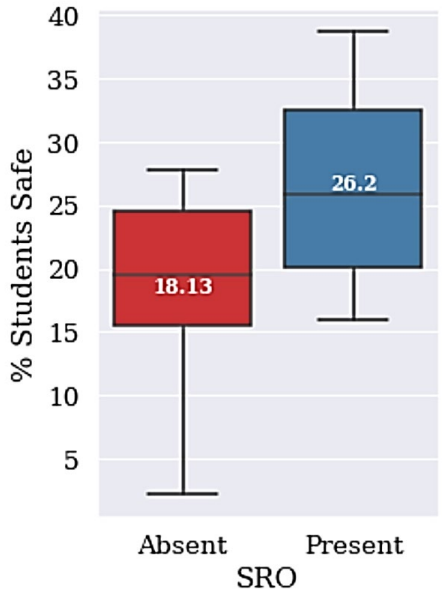
Figure 3-5. Shots Fired by the Shooter Across All Runs, Broken Down by SRO Presence.



3.1.3 Student Safety

Percentage of students evacuated or in locked classrooms at the end of the run was significantly higher when the SRO was present, including both human-operated and AI students (median 26 percent versus 19 percent; mean 26 percent versus 18 percent; p=.007) (see Figure 3-6).

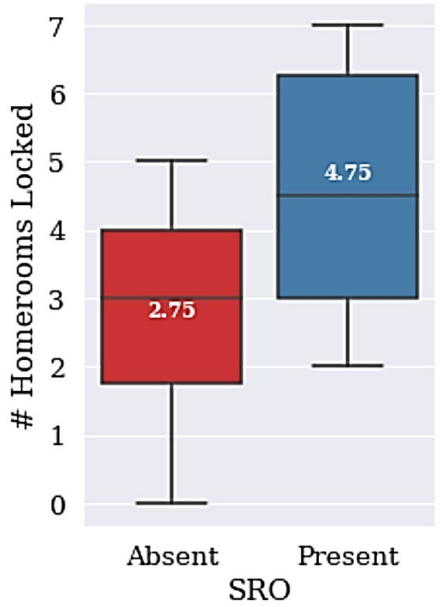
Figure 3-6. Percentage of Students Evacuated or in Locked Classrooms at the End of the Run, Across All Runs, Broken Down by SRO Presence.



3.1.3.1 Related Metric: Number of Classrooms in Lockdown

For further insights on student safety, the number of homerooms successfully closed and locked at the end of a run (out of 10) was analyzed. This number was significantly higher when the SRO was present (median 4.5 versus 3.0; mean 4.8 versus 2.8; p=.006) as shown in Figure 3-7.

Figure 3-7. Number of Classrooms Locked Down Across All Runs, Broken Down by SRO Presence.



In addition to pursuing the shooter, the SRO tried to secure the school and ensure students and teachers were in locked classrooms, a behavior that could have allowed more classrooms to lock successfully. Teacher operators reported this behavior in survey feedback:

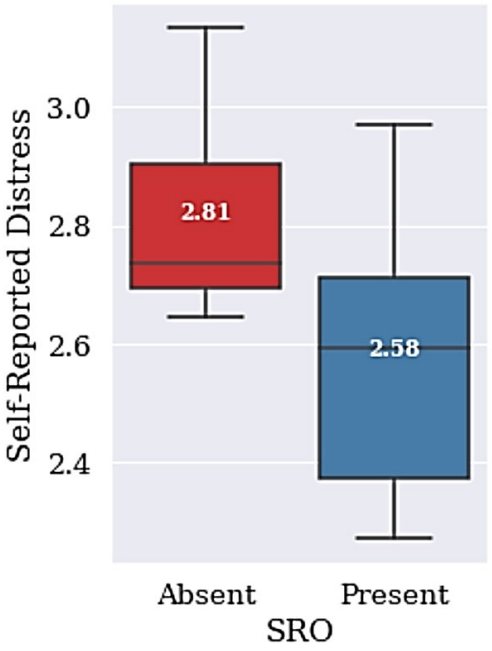
"Heard gunshots, SRO told us to go into lock down, students and I went into our homeroom and I locked the door, and lastly admin made an announcement about an active shooter."

- "My door was already locked and shut, so I went to go unlock it. I keep it open for a few more seconds for students that still needed a room to be in. I went inside when I saw the SRO pass by."
- "The runs with no SRO and manual locks, are the WORSE [sic] runs."

3.1.4 Participant Distress

Participants felt significantly less emotional stress on a 10-point scale (p=.014) during the runs when the SRO was present. When averaged among all students, teachers, and the administrator in a run, runs with an SRO had a mean SUDS score of 2.6 versus 2.8 (p=.037; see Figure 3-8). While the SUDS score has a maximum of 10, average distress ranged from 2.3 to 3.1 across all runs in this experiment.

Figure 3-8. Self-reported Emotional Distress for All Participants Across All Runs, Broken Down by SRO Presence.



3.1.5 Other Observations and Feedback

The SRO was killed in 11 out of 12 record runs, while the shooter was only killed in one run (in which the SRO was also killed at the same instant). This is not surprising given that the SRO had to exercise careful judgment when deciding to shoot while the shooter was willing to shoot indiscriminately. Therefore, the SRO's success at ensuring student safety and reducing casualties was apparently not because of direct confrontation with the shooter but rather because of the impact of the SRO on the behaviors of the other participants. Based on the data described in this section, the SRO lowered stress among the students and teachers, encouraged teachers to close their classrooms, and acted as a deterrent for the shooter. Improved situational awareness may have improved the SRO's performance in direct confrontation with the shooter. See Appendix J for further discussion of the SRO's and shooter's situational awareness.

3.2 Door-Locking Policy

Pre-locked doors were found to have a significant effect on student safety as implemented in the SIMEX. Despite this, as explained in Section 3.2.5, door-locking policy was not found to have any significant effect on casualties in this experiment.

As noted in Section 2.8.4, the shooter did not know initially whether doors were pre-locked. The shooter could determine whether doors were locked by viewing the light indicators on the locking mechanisms.

3.2.1 Impact on the Scenario Timeline

When doors were pre-locked, the shooting happened earlier and was more concentrated in time (median first shots 3.2 versus 3.6; mean 3.5 minutes versus 4.2 minutes) as shown in Figure 3-9 and Figure 3-10. Casualties were concentrated in the first five minutes of these runs, while when doors were manually locked more casualties occurred between five and eight minutes into the run.

The shooter was very strategic and thought carefully about potential obstacles. The shooter often observed the door lights to determine if doors were pre-locked at the start of the run. It seems that the presence of limitations encouraged the shooter to focus more exclusively on the mission and execute in a more efficient manner that often resulted in shooting earlier.

When the doors were pre-locked, the shooter implemented a different strategy because there was limited time after the lockdown to access students in classrooms. In one debrief, the shooter described, "my goal was to get somewhere safe" (meaning a locked classroom while pretending to be a regular student) because the doors were pre-locked. He stated he would have a different strategy if the doors were not pre-locked. In the case just mentioned, he had a goal to enter the classroom with the other students prior to the teacher closing the door. He subsequently shot all students in this room. These kinds of strategies would concentrate the casualties earlier in the run.

Figure 3-9. Timeline of Important Scenario Events Across All Runs Broken Down by Door-locking Policy.

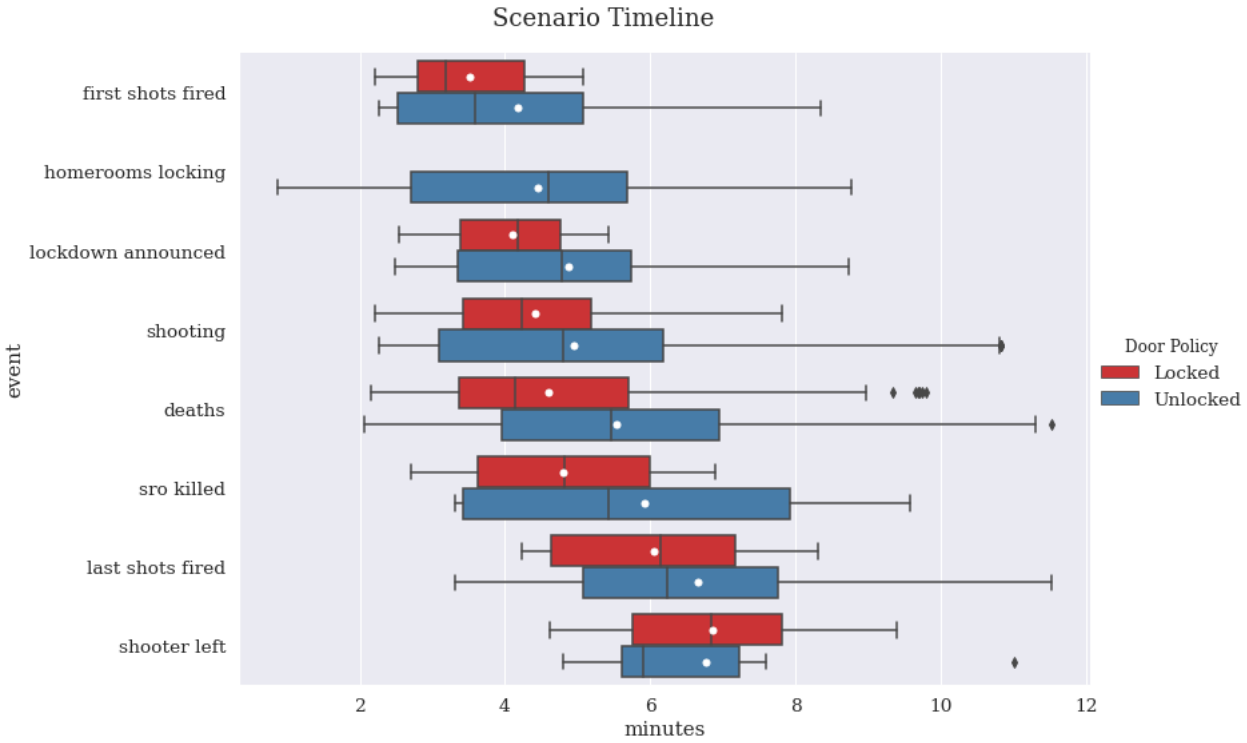
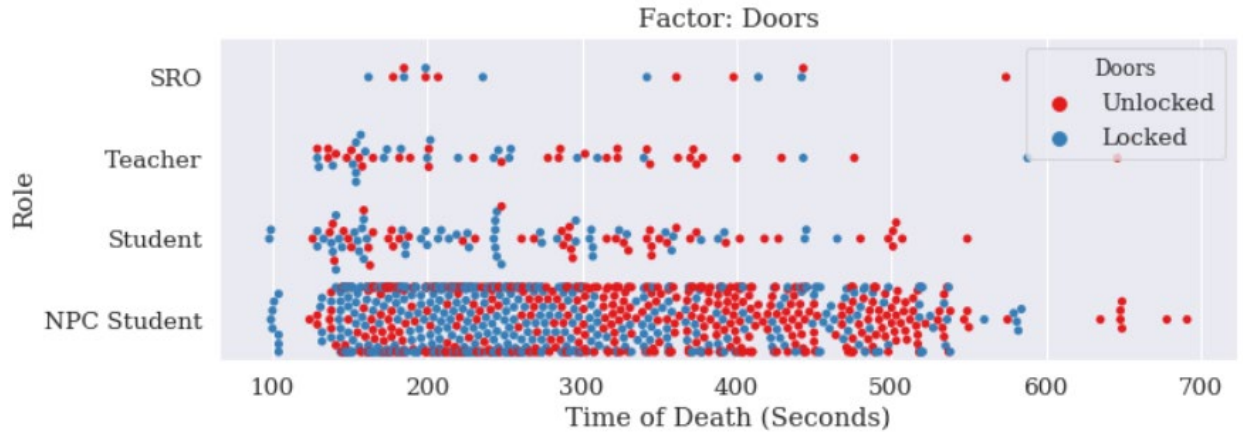


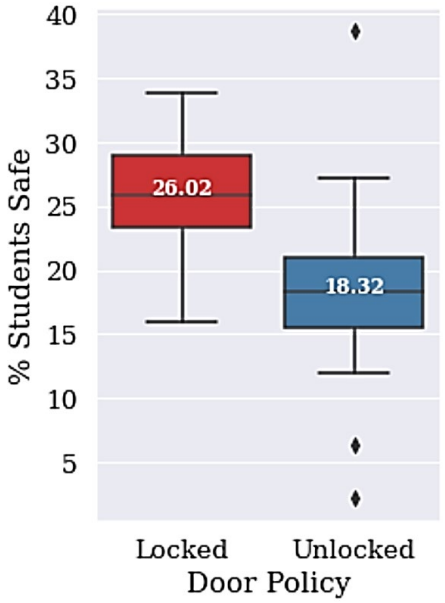
Figure 3-10. Swarm Plot Showing Casualties Over Time Across All Runs Broken Down by Door-locking Policy.



3.2.2 Student Safety

Percentage of students evacuated or in locked classrooms at the end of the run was significantly higher when doors were pre-locked, including human-operated and computer-generated students (median 26 percent versus 18 percent; mean 26 percent versus 18 percent; p=.010) (see Figure 3-11).

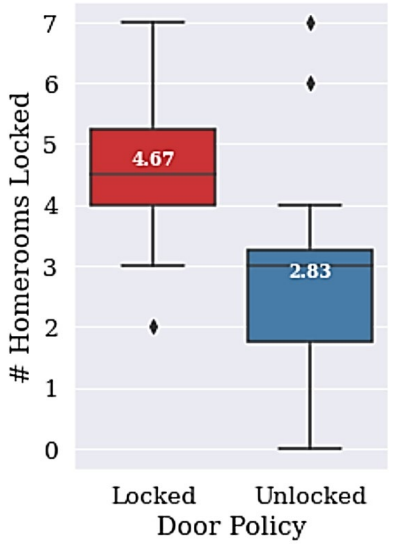
Figure 3-11. Percentage of Students Evacuated or In Locked Classrooms at the End of the Run, Across All Runs, Broken Down by Door-locking Policy. [17]



3.2.2.1 Related Metric: Number of Classrooms in Lockdown

The number of homerooms (out of 10) successfully closed and locked at the end of a run was analyzed and is illustrated in Figure 3-12. This number was significantly higher when doors were pre-locked (median 4.5 versus 3.0; mean 4.7 versus 2.8; p=.011).

Figure 3-12. Number of Classrooms Locked Down Across All Runs, Broken Down by Door-locking Policy.



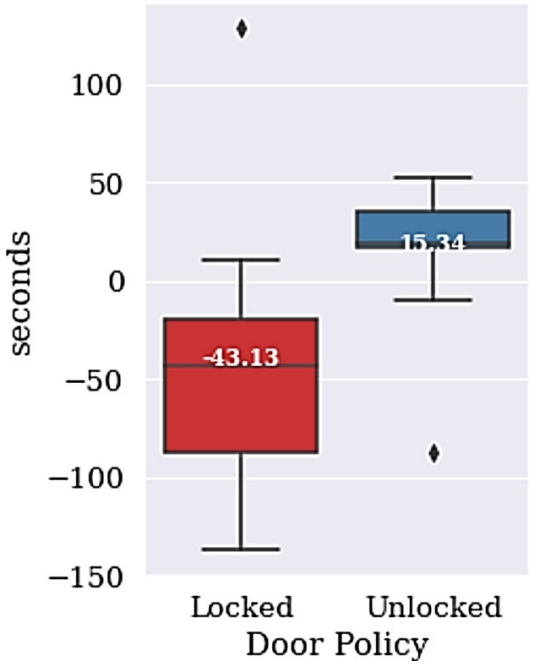
[17] For the results graphs comparing door policy, "locked" refers to the pre-locked doors and "unlocked" refers to the doors that had to be manually locked.

3.2.3 Average Time to Complete Lockdown

This metric is the time from when the shooter drew his weapon to fire to the time that a classroom was closed and locked, averaged across all homerooms in a run (see Figure 3-13).

It was discovered in data analysis that most teachers (between six and all 10 per run) had already closed their classroom doors before any threat was realized.[18] In runs with manual locks, teachers had to open their doors and lock them when a threat was realized. In runs with pre-locked doors this extra step was not required. Because in the pre-locked runs some teachers' doors were closed (and therefore locked) even before threat onset, this metric was less than zero in some cases. In runs with pre-locked doors the time to lockdown was significantly lower than in runs with manual locks (median -44 seconds or 44 seconds before threat versus 19 seconds after threat onset; mean 43 seconds before threat to 15 seconds after threat onset; p=.011).

Figure 3-13. Average Time to Classroom Lockdown for All Classrooms Across All Runs, Broken Down by Door-locking Policy.



3.2.4 Other Observations and Feedback

3.2.4.1 Teacher Frustration

Post-run survey feedback from teacher operators indicated that they felt frustrated and unsafe in runs with manual locks:

- "A student kept opening the door which prevented me from being able to lock it."
- "Since I was unable to lock the door, I tried to usher the students quickly out the front door [to the outside of the school]."
- "I tried locking my door, but because it takes forever to lock doors when its [sic] manual locks, I couldn't get the door closed."
- "If the door wasn't a manual lock, but instead automatic, then I think I would've made it out alive, because all I would've had to do was close my door. Excuse my language, but the manual locks piss me off so much."

[18] It is unknown to what extent this was due to teachers' anticipation of a threat and to what extent it reflected teachers' behaviors on a normal school day.

3.2.4.2 Casualties in Locked Classrooms

Unlike in the case of the SRO, door-locking policy was not found to have any significant effect on casualty percentages. In other words, the measurable benefits of pre-locked doors to student safety did not translate into a lower casualty count.

One possible explanation for this discrepancy between student safety and casualty count is casualties inside locked classrooms. According to the data, in 12 out of 24 record runs human-operated students, teachers, and NPCs were shot inside classrooms that were locked either at the time or by the end of the run. In most cases the number of people killed inside locked classrooms was less than five. Possible reasons for this statistic include:

- In the hotwashes for at least three different runs, students and teachers shared that they believed they were shot by stray bullets through walls. While the school model did not accurately model architecture physics and cannot predict real bullet trajectories, it is worth noting that people can be shot through walls.
- Classroom doors may have been closed and locked after or while being visited by the shooter. The shooter employed a variety of strategies, often posing as a regular student to get inside classrooms before they were locked. For example, on run 8 (a pre-locked run) the shooter entered room 209 before the door closed. While he was inside the classroom, the door was closed from the outside, effectively locking out the shooter's target. The shooter re-opened the door while he waited for the target to arrive. Once the target arrived, the shooter eliminated everyone in the room and left. In addition, the shooter could use the door locks to prevent others from observing or interrupting his activities. On runs 10 and 14 the shooter entered the target classroom, shut the door, which was pre-locked, and eliminated everyone inside. In the debrief for run 10, he explained that his goal was to get somewhere safe because he knew doors were locked and that he would have implemented a different strategy if the doors had not been automatically locking.
- There was a technical issue during run 2. The shooter perceived classroom 106 as unlocked and opened it, even though it should have been pre-locked. This problem was likely due to data being lost over the network and occurred only this one time.

3.3 Lockdown Notification Policy

In runs with decentralized notification when teachers were directed to use the PA system, they used it not just for initial notification of a threat but for subsequent updates on the threat. This proliferation of information throughout the school might have been expected to raise situational awareness and also to produce noise.[19]

The manner of lockdown notification was not found to have any significant statistical effects on the metrics. There were not significant impacts to the time that the front office issued the lockdown announcement or the time that classrooms entered lockdown.

Possible effects worth exploring are reviewed in this section.

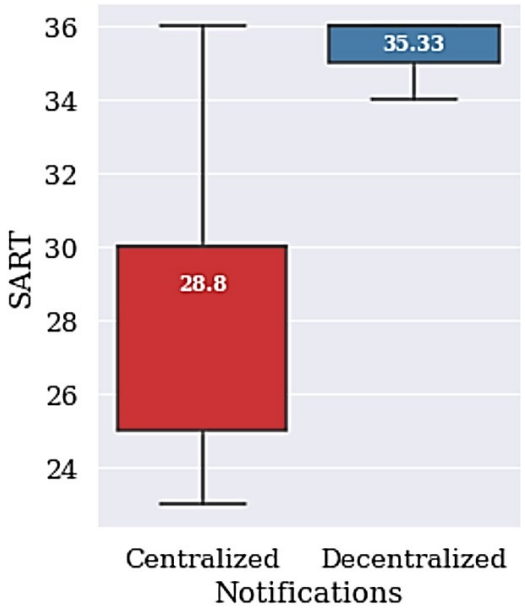
3.3.1 SRO Situational Awareness

When teachers gave notifications over the PA (decentralized notifications) the SRO reported consistently high situational awareness. In centralized notification runs when the SRO received information only from the front office, his self-reported situational awareness varied over the range of possible responses as shown in Figure 3-14. The SRO's average SART score was 35 in runs with decentralized notifications as opposed to 29; the SRO's SART score ranged from 23 to 38 over the course of the experiment.[20]

[19] Due to COVID-related staffing restrictions and limitations of the distributed technical infrastructure, the data collection team was not able to observe or record teachers' interactions with the PA system. Participants did describe how the PA system was used in their hotwash feedback.

[20] The SART score is not reported with an absolute maximum since its computation is complex and does not reference a linear scale. Rather the SRO's minimum and maximum reported values are given for reference.

Figure 3-14. SRO's Self-Reported Situational Awareness, Broken Down by Lockdown Notification Policy.



On runs with centralized notifications, the SRO noted a significant lag in notification information, such that information about the shooter was out of date by the time it was communicated.

- From post-run survey: "Shots fired, admin gave location of shooter, responded to cafeteria and began searching. Followed bodies around school, before admin reported shooter was outside."
- From post-run hotwash: "The first thing I noticed was… the delay of information… When admin received that information that the shooter was in the green hallway… I know from watching the screen that the shooter had already made it through the green hallway, through the purple hallway, and I would guess was going down the teal hallway before that information made it to admin. To me that speaks volumes that timely information is critical, to get that information out to the school and to lock it down."

Despite this impact on the SRO's self-reported situational awareness, no improvements to student safety or casualty percentages were found. Though perceived by the SRO to be better, this difference in situational awareness was apparently still not sufficient to mitigate the shooter's impact. See Appendix J for a more detailed discussion of situational awareness.

3.3.2 Other Observations and Feedback

Although not significantly supported by the data, there is evidence that the shooter took advantage of the notifications to stay ahead of the awareness of the other participants. Knowing where the SRO would be headed, the shooter could easily choose a safe path. This behavior was noted in the shooter's post-run survey feedback and debriefs:

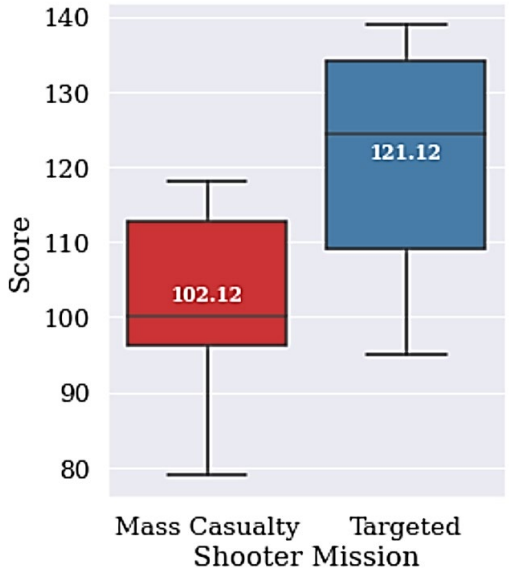
- "I went back to the blue hallway where I heard an announcement about where I was and what I was wearing. Then I checked the red hallway before running out of ammo and escaping to the outdoor sports fields through stair 122."
- "I heard an announcement about lockdown and that they knew I was in the green hallway."
- "My movements were being broadcast through the school, so I made my way to the black hallway and shot people there because I knew that no classrooms were around."
- "I could hear announcements over the PA about my description and location."
- "When I heard that they had my location in purple hallway, I got as far away as possible."

3.4 Other Measured Effects

3.4.1 Effect on Shooter of Targeted Versus Mass Casualty Runs

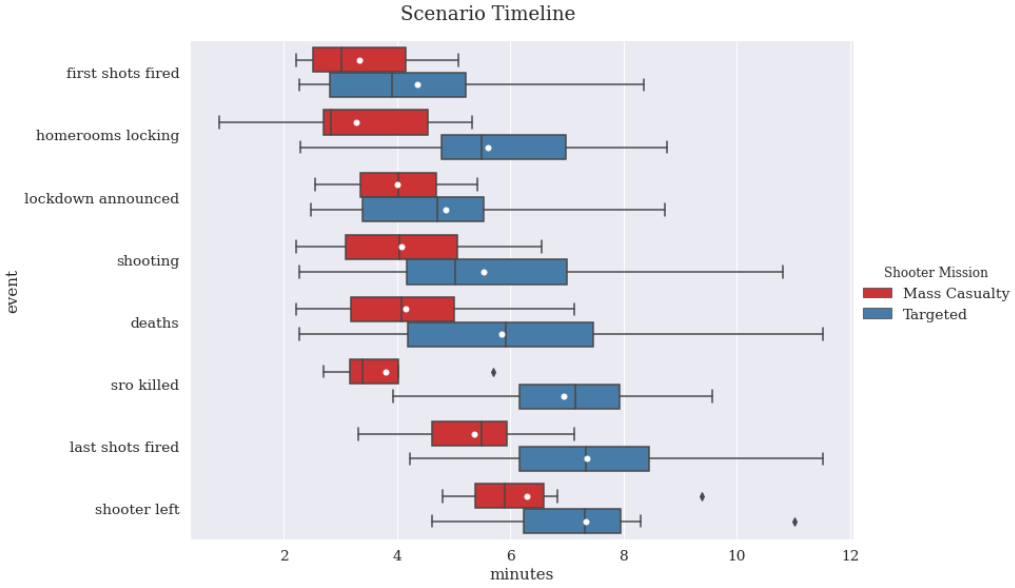
The shooter reported significantly lower workload on mass casualty runs. The shooter's average NASA-TLX score was 102.12 in mass casualty runs, compared to 121.12 in targeted runs. The shooter's NASA-TLX score ranged from 79 to 139 over the course of the experiment (see Figure 3-15). [21]

Figure 3-15. Shooter's Self-Reported Workload, Broken Down by Shooter Mission.



The shooter opened fire earlier (median first shots 3.0 versus 3.9; mean first shots 3.3 minutes versus 4.4 minutes; median last shots 5.5 versus 7.3; mean last shots 5.4 minutes versus 7.4 minutes) and left the school earlier (median 5.9 versus 7.3; mean 6.3 minutes versus 7.3 minutes) in mass casualty runs (see Figure 3-16).

Figure 3-16. Timeline of Important Scenario Events Across All Runs Broken Down by Shooter Mission.



[21] The NASA-TLX score is not reported with an absolute maximum since its computation is complex and does not reference a linear scale. Rather the SRO's minimum and maximum reported values are given for reference.

Post-run survey feedback and debriefs from the shooter and others indicates that the shooter took time to strategize and wait for the target during targeted runs:

- "I walked around in order to waste time in the beginning of the run. Then I looped around the blue hallway twice, once to scout and once to initiate my plan."
- "Not looking to blow my cover I went into that room and crouched in the corner."
- "I waited in the guidance counselor's office for a long time. Then I went into room 200 upstairs where I realized that there was no desk. I then shot the person who was beckoning us into the classroom, who I assumed to be the teacher. I then proceeded to blend in with the students who were escaping by running towards the blue/teal stairway."
- "The shooter went inside room 210 and sat at the center of class. I interacted with all students, him included. When the room 210 got crowded, the shooter said, 'hey look at my TI-84.'"
- "When I arrived, the teacher was outside the room so I waited until he entered."
- "I scouted out room 200, pretended to run a mission, then left and hid. I scouted out room 200 again, watching people going in and out. I figured out who the teacher was [and shot him]."

SECTION 4: CONCLUSIONS

Each of the following paragraphs addresses a different independent variable and blends the results of the confirmatory analysis of quantitative metrics with exploratory analysis of survey comments for a full summary of the variable's effect.

The presence of an SRO was found to have a statistically significant impact on the outcome of an active school shooter event. Hypothesis One was supported by the data. **In runs with an SRO, more students got safely outside the school or into locked classrooms and there were fewer casualties than in runs with no SRO. In addition, participants self-reported less distress in runs with an SRO.** Emergent themes in the survey comments highlighted the presence of the SRO as a critical resource for stress mitigation and student safety. According to survey comments, when the SRO was absent, responsibility for school safety shifted to teachers who felt overwhelmed and ineffective without the SRO. The shooter's survey comments revealed a focus on circumventing and eliminating the SRO, frequently referencing strategies such as hiding or 'blending in' as a student.

Classroom doors that lock without teacher intervention when closed were found to have a statistically significant impact on the outcome of an active school shooter event. Hypothesis Two was partially supported by the data. **In runs with pre-locked doors, more classrooms completed lockdown procedures and more students got safely outside the school or into locked classrooms. However, there was no significant difference in casualties in this experiment.** Participants expressed widespread frustration with the manual locks and self-reported lower workload in runs with pre-locked doors.

Allowing teachers to give lockdown notifications over the PA system (the decentralized mode) did not have a significant impact on the outcome of an active shooter event. Hypothesis Three therefore was not supported by the quantitative data in this SIMEX. In survey comments, while centralized notifications were viewed as precise and efficient, operators felt decentralized notifications were more reliable. Although the SRO and others reported higher situational awareness when lockdown notifications were decentralized, the shooter also took advantage of these communications.

No significant differences on safety outcomes were found between targeted and mass casualty shooting scenarios in this SIMEX as indicated by the outcome metrics. The number of casualties in mass casualty runs was higher but not significantly higher than targeted runs ($p=.056$). However, exploratory analysis of survey comments revealed differences in the participants' perceptions of targeted and mass casualty runs. According to survey comments, mass casualty runs produced higher levels of emotional stress, presented significant communication challenges, and yielded lower situational awareness than targeted runs for all operators besides the shooter. Targeted runs, while longer on average, yielded stronger adherence to lockdown protocols and more efforts to ensure students were safe. The shooter reported more frustration and workload during targeted runs, which required more careful planning.

SECTION 5: RECOMMENDATIONS

This SIMEX examined three experimental factors associated with school policies that hypothetically could affect the outcome of an active shooter scenario. There are four recommendations based on the SIMEX results. These recommendations are not prioritized, and it is critical that each be considered in accordance with relevant state and/or district requirements and regulations as well a school's existing policies, procedures, and operations.

1. The presence of an SRO in this experiment reduced casualties and increased the number of students able to remain safe during an active school shooter event. As a result, **schools should consider the use of an SRO or equivalently trained security professional(s)** as a component of a layered security approach.
2. While an SRO's presence improved the safety of students and teachers during lockdown, their situational awareness was not sufficient to neutralize the shooter in an active shooter incident. To address this challenge, **schools should investigate potential strategies or technologies that improve the timeliness and accuracy of an SRO's** (or external law enforcement's) **situational awareness** to support the observing, processing, and decision-making process.
3. Given that pre-locked classroom doors may increase the number of students able to remain safe during an active school shooter event, **schools should consider establishing a policy to require that classroom doors be kept in the locked position at all times** during morning, daily, and departure periods where possible. Alternately, **schools could also consider adopting technology for automatically locking all classroom doors** when a lockdown is issued. Such a policy and/or technology could play a role in developing an effective, comprehensive security strategy.
4. A lockdown notification policy did not yield any clear effects in this experiment due to the finding that while decentralized notifications may have improved situational awareness, they did not seem to aid school security or mitigation of the shooter. In fact, there is evidence that the shooter benefitted from the PA notifications in completing their mission. As a result, **schools should consider developing a communications strategy/plan that allows for students, teachers, administrative staff, and an SRO** (or external law enforcement) **to effectively and efficiently share information** and updates with one another. Schools could also **consider investigating modern communications technologies** that could supplement such a strategy or policy.

SECTION 6: LIST OF REFERENCES

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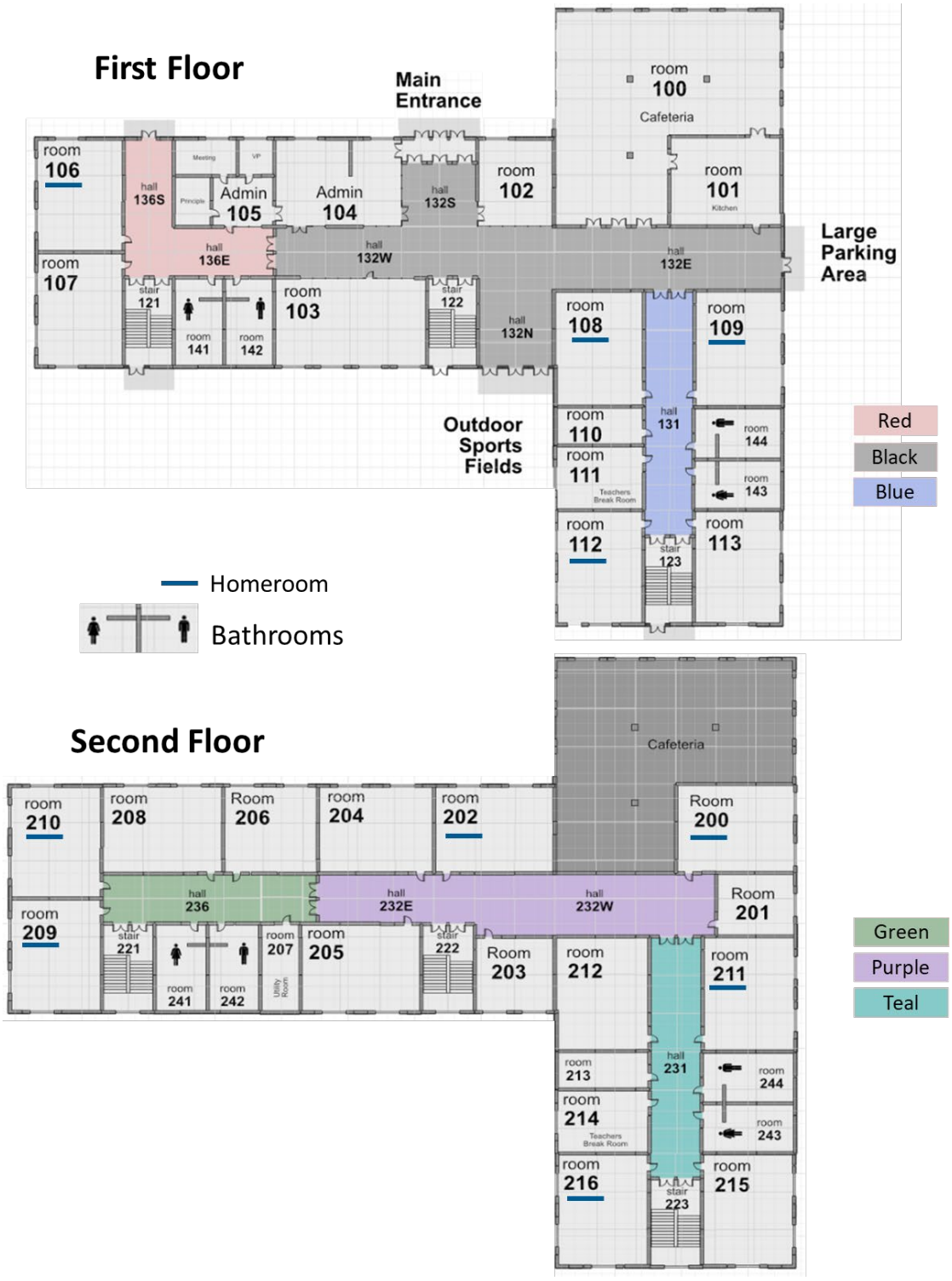
APPENDIX A: SCHOOL LAYOUT

Figure A-1. Layout of School Model.



APPENDIX B: SURVEYS

B.1 Pre-SIMEX Survey

The following survey is designed to gather information on the operators participating in SIMEX 20-6 including demographic and background information. Please complete the survey to the best of your abilities. If you have questions, request a member of the data collection team come assist you.

There are nine questions in this survey.

B.1.1 Participant Demographics

Questions in this section are to collect information for the final report and contact information if we need to contact you during the experiment.

**Select the identity and position you have been assigned:*

Your unique identity is composed of an alphanumeric code, your role in the SIMEX, and your pseudonym or real name if you haven't been provided with a pseudonym.

** Phone Number: (Non-students only)*

B.1.2 Awareness of School Security

How strongly do you agree or disagree with the following statements regarding your awareness of school security?

Please choose the appropriate response for each item:

Figure B-1. Awareness of School Security Responses.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am aware of the procedures when there is an active shooter at a school.					
I am well informed on cases of active shooters in schools.					

B.1.3 Perception of Importance to School Security

Please rate how important you think the following are in preventing loss of life in active shooter situations:

** Please rate how important you think the following are in preventing loss of life in active shooter situations. Please choose the appropriate response for each item:*

Figure B-2. Perception of Importance to School Security Responses.

	5 - Extremely Important	4 - Moderately Important	3 - Somewhat Important	2 - Slightly Important	1 - Not at all Important
School resource officers					
Armed school resource officers					
Armed school staff					
Ability to lock doors					
Policy of locked doors during classes					
Staff preparedness					
Student preparedness					
Early detection of shooter's intent					
Metal detectors					
Staff intervention with shooter					
Staff initiation of active shooter emergency protocol					
Student initiation of active shooter emergency protocol					
Panic buttons in classrooms					
Covering windows					
School layout					
Successfully isolating the shooter					
Using classroom blind spots					
Exterior barriers					
Limiting school access points					

B.1.4 Overall Feelings of Public High School Safety for Students/Faculty

School safety evaluation. Please choose the appropriate response for each item:

Figure B-3. Overall Feelings of Public High School Safety for Students/Faculty Responses.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel safe before and after school while on school grounds.					
I feel safe when I am in my classrooms.					
I feel safe in the school hallways.					
I feel that security procedures at my school are effective.					

Respond to these questions regarding your perception of school safety in the United States K-12 School Systems.

B.1.5 Level of Comfort with the Experiment

The Subjective Units of Discomfort Scale (SUDS) is a frequently used self-report measure which provides subjective information regarding an individual's level of discomfort and/or distress (Kim, Bae, & Park, 2008). Ratings on the one-item measure follow a 10-point scale to indicate levels of discomfort ranging from 0 = "no discomfort" to 10 = "highest discomfort ever felt." Ratings are intended to capture your level of comfort related to your participation in the experiment.

** Rate your level of comfort with the experiment:*

Please choose only one of the following:

- Totally comfortable with the experiment (1)
- Mostly comfortable with the experiment (2)
- Somewhat comfortable with the experiment (3)
- Mild discomfort with the experiment (4)
- Mild-to-moderate discomfort, some elements are bothersome (5)
- Moderate discomfort; concerned but will participate (6)
- Moderate-to-strong discomfort; have considered not participating (7)
- Strong discomfort; considering not participating (8)
- Extreme discomfort; signs of distress present when I think about participating (e.g., nausea, sweating, fatigue, headache) (9)
- Highest level of discomfort ever felt, I do not want to participate in the experiment (10)

If you experience any physical or emotional discomfort due to your participation in the experiment, let a member of the research team know as soon as possible. While the research team will check in with all operators before and after each run, if you need to speak to someone about feelings of discomfort or distress, you are free to do so at any time. You are also free to take a break or stop your participation in the experiment at any time.

** I have read and understand what to do if I am distressed.*

Please choose only one of the following:

- Yes
- No

B.1.6 COVID Screening

COVID-19 Screening verification.

** Have you submitted today's COVID-19 screening to the research team? **

Please choose only one of the following:

- Yes
- No

Submit your survey. Thank you for completing this survey.

B.2 AM Baseline Survey

The following survey is designed to gather information on your baseline this morning. Please complete the survey to the best of your abilities. If you have questions, request a member of the data collection team come assist you.

There are six questions in this survey.

B.2.1 Participant Demographics

Questions in this section are to collect information for the final report and contact information if we need to contact you during the experiment.

**Select the identity and position you have been assigned:*

Your unique identity is composed of an alphanumeric code, your role in the SIMEX, and your pseudonym or real name if you haven't been provided with a pseudonym.

** Select Today's Date:*

- Tuesday, August 4
- Wednesday, August 5
- Thursday, August 6
- Friday, August 7
- Monday, August 10
- Tuesday, August 11
- Wednesday, August 12
- Thursday, August 13
- Friday, August 14

B.2.2 Level of Comfort with the Experiment

The Subjective Units of Discomfort Scale (SUDS) is a frequently used self-report measure which provides subjective information regarding an individual's level of discomfort and/or distress (Kim, Bae, & Park, 2008). Ratings on the one-item measure follow a 10-point scale to indicate levels of discomfort ranging from 0 = "no discomfort" to 10 = "highest discomfort ever felt." Ratings are intended to capture your level of comfort related to your participation in the experiment.

* Physical Discomfort: Select one of the following statements to reflect current level, or baseline, of physical discomfort.

Please choose only one of the following:

- No physical discomfort; totally comfortable (1)
- Alert and awake; feeling physically well (2)
- Minimal physical discomfort (3)
- Mild physical discomfort; no interference with functioning (4)
- Mild to moderate physical discomfort (5)
- Moderate physical discomfort; uncomfortable, but can continue to function (6)
- Moderate to strong physical discomfort (7)
- Strong physical discomfort; interfering with functioning. Physiological signs may be present (e.g., nausea, sweating, fatigue, gastrointestinal distress) (8)
- Extreme physical discomfort; can't concentrate. Physiological signs present (e.g., nausea, sweating, fatigue, gastrointestinal distress) (9)
- Highest level of physical discomfort you have ever felt (10)

* Emotional Discomfort: Select one of the following statements to reflect your current level, or baseline, of emotional discomfort.

Please choose only one of the following:

- No distress; totally relaxed (1)
- Alert and awake; concentrating well (2)
- Minimal anxiety/distress (3)
- Mild anxiety/distress; no interference with functioning (4)
- Mild to moderate anxiety or distress (5)
- Moderate anxiety or distress; uncomfortable, but can continue to function (6)
- Moderate to strong anxiety or distress (7)

- Very anxious/distressed; interfering with functioning. Physiological signs may be present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (8)
- Extremely anxious/distressed; can't concentrate. Physiological signs present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (9)
- Highest anxiety/distress you have ever felt (10)

* If you experience any physical or emotional discomfort due to your participation in the experiment, let a member of the research team know as soon as possible. While the research team will check in with all operators before and after each run, if you need to speak to someone about feelings of discomfort or distress, you are free to do so at any time. You are also free to take a break or stop your participation in the experiment at any time. I have read and understand what to do if I am distressed. Please choose only one of the following:

- Yes
- No

B.2.3 COVID Screening

COVID-19 Screening verification.

* Have you submitted today's COVID-19 screening to the research team?

- Yes
- No

Thank you for completing this survey. We have recorded your response! Leave this page up until the start of the first run in case there are any issues retrieving your data.

B.3 Post-Run Survey

The following survey is designed to gather information run that was just executed in SIMEX 20-6, including specific outcomes, the workload and any emotional or physical distress. Please complete the survey to the best of your abilities. If you have questions, request a member of the data collection team come assist you.

There are 22 questions in this survey.

B.3.1 Participant Demographics

Questions in this section are to collect information for the final report and contact information if we need to contact you during the experiment.

**Select the identity and position you have been assigned:*

Your unique identity is composed of an alphanumeric code, your role in the SIMEX, and your pseudonym or real name if you haven't been provided with a pseudonym.

** Enter the Run Number:*

[Numeric Entry]

B.3.2 Run Outcomes

Answer the following questions to provide details on the outcomes of the experiment run.

* (Red Team Only) Which type of mission were you completing? Please choose only one of the following:

- Targeted
- Maximum casualties
- Other

* I was shot during the experiment run. Please choose only one of the following:

- Yes
- No

Select "No Answer" if you do not know.

What did you observe during the experiment run?

Please choose all that apply:

- I saw the active shooter
- I saw the shooter get apprehended/overpowered
- I saw a teacher get shot
- I saw two or more teachers get shot
- I saw one student get shot
- I saw two of more students get shot

What actions did you take during the experiment run? Please choose all that apply:

- Locked doors
- Initiated emergency protocol
- Took action against the shooter
- Took cover from the shooter
- Ran or took action to evade the shooter
- Other:

Leave this question blank if you did not take any actions.

What caused the run to end? Please choose all that apply:

- Unknown
- Shooter surrendered
- Shooter apprehended/overpowered
- Shooter left the premise
- Shooter verbally requested run to end

(Teachers, Admin, SRO, and Red Team only) Briefly describe what happened during the run from your perspective. Please write your answer here:

- [Free Response]

Please document if anything did not work as expected during the run. You also must report this to a SIMEX staff member in-person. Please write your answer here:

- [Free Response]

B.3.3 Workload

The Official NASA Task Load Index (TLX) is a subjective workload assessment tool to allow users to perform subjective workload assessments on operator(s) working with various human-machine interface systems. Originally developed as a paper and pencil questionnaire by NASA Ames Research Center's Sandra Hart in the 1980s, NASA TLX has become the gold standard for measuring subjective workload across a wide range of applications.

This section was only distributed to teachers, the admin, the SROs, and the red team.

* Mental Demand. How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)?

1=Low Demand -> 20=High Demand

- Select a Number 1-20.

* Effort. How hard did you have to work (mentally and physically) to accomplish your level of performance?

1=Low Effort -> 20=High Effort *

- Select a Number 1-20.

* Temporal Demand. How much time pressure did you feel due to the rate or pace at which tasks or task elements occurred?

1=Low Demand -> 20=High Demand *

- Select a Number 1-20.

* Performance. How successful do you think you were in accomplishing the goals of the scenario? How satisfied were you with your performance in accomplishing these goals?

1=Poor Performance -> 20=Excellent Performance *

- Select a Number 1-20.

* Frustration. How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?

1=Low Frustration -> 20=High Frustration *

- Select a Number 1-20.

B.3.4 Situational Awareness

The Situational Awareness Rating Technique is a multi-dimensional rating technique (Taylor 1990). The three primary SART rating dimensions, corresponding to the three clusters of the original constructs elicited from military aircrews are:

1. Demand on attentional resources
2. Supply of attentional resources
3. Understanding.

* The following statements are meant to evaluate the demand on mental and physical resources during the run. Please choose the appropriate response for each item. Please indicate how Low (1) or High (7) the experiment run was in terms of:

Figure B-4. Situational Awareness Responses (1/3).

	1 (Low)	2	3	4	5	6	7 (High)
Instability of situation (likeliness to change suddenly)							
Variability of situation (number of variables and factors changing)							
Complexity of situation (degree of complication)							

* The following statements are meant to evaluate your availability of mental and physical resources. Please choose the appropriate response for each item. Please indicate how Low (1) or High (7) the experiment run was in terms of: *

Figure B-5. Situational Awareness Responses (2/3).

	1 (Low)	2	3	4	5	6	7 (High)
Alertness (degree of alertness or readiness for action)							
Spare mental capacity (mental ability available for new variables)							
Concentration of attention (degree to which thoughts are brought to bear)							
Division of attention (ability to divide your attention among several key issues)							

* The following statements are meant to evaluate your understanding of the situation. Please indicate how Low (1) or High (7) the experiment run was in terms of: *

Please choose the appropriate response for each item:

Figure B-6. Situational Awareness Responses (3/3).

	1 (Low)	2	3	4	5	6	7 (High)
Information quantity (amount of knowledge received and understood)							
Information quality (degree of goodness or value of knowledge communicated)							
Familiarity (degree of acquaintance with the situation)							

B.3.5 Virtual Reality Feedback

Please let us know how VR is working for you in the experiment and if you are experiencing any issues with your use of the VR environment.

* Please let us know which of the following symptoms, if any, you have or are currently experiencing as a result of using VR. *

Please choose all that apply:

- None
- Nausea
- Dizziness
- Sweating
- Pallor (light headed)
- Vomiting
- Postural instability (unstable while standing, felt you needed to sit down)
- Other:

B.3.6 Level of Comfort with the Experiment

The Subjective Units of Discomfort Scale (SUDS) is a frequently used self-report measure which provides subjective information regarding an individual's level of discomfort and/or distress (Kim, Bae, & Park, 2008). Ratings on the one-item measure follow a 10-point scale to indicate levels of discomfort ranging from 0 = "no discomfort" to 10 = "highest discomfort ever felt". Ratings are intended to capture your level of comfort related to your participation in the experiment.

* Emotional Discomfort During the Run: Select one of the following statements to reflect your level of emotional distress during the run. *

Please choose only one of the following:

- No distress; totally relaxed (1)
- Alert and awake; concentrating well (2)
- Minimal anxiety/distress (3)
- Mild anxiety/distress; no interference with functioning (4)
- Mild to moderate anxiety or distress (5)
- Moderate anxiety or distress; uncomfortable, but can continue to function (6)
- Moderate to strong anxiety or distress (7)
- Very anxious/distressed; interfering with functioning. Physiological signs may be present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (8)
- Extremely anxious/distressed; can't concentrate. Physiological signs present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (9)
- Highest anxiety/distress you have ever felt (10)

Emotional Discomfort Now: Select one of the following statements to reflect your level of emotional distress at this current moment.

Please choose only one of the following:

- No distress; totally relaxed (1)
- Alert and awake; concentrating well (2)
- Minimal anxiety/distress (3)
- Mild anxiety/distress; no interference with functioning (4)
- Mild to moderate anxiety or distress (5)
- Moderate anxiety or distress; uncomfortable, but can continue to function (6)
- Moderate to strong anxiety or distress (7)
- Very anxious/distressed; interfering with functioning. Physiological signs may be present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (8)
- Extremely anxious/distressed; can't concentrate. Physiological signs present (e.g., sweating, shaking, increased heart rate or respiration, gastrointestinal distress) (9)
- Highest anxiety/distress you have ever felt (10)

* Physical Discomfort: Select one of the following statements to reflect current level of physical discomfort related to engaging in VR. *

Please choose only one of the following:

- No physical discomfort; totally comfortable (1)
- Alert and awake; feeling physically well (2)
- Minimal physical discomfort (3)
- Mild physical discomfort; no interference with functioning (4)
- Mild to moderate physical discomfort (5)
- Moderate physical discomfort; uncomfortable, but can continue to function (6)
- Moderate to strong physical discomfort (7)
- Strong physical discomfort; interfering with functioning. Physiological signs may be present (e.g., nausea, sweating, fatigue, gastrointestinal distress) (8)

- Extreme physical discomfort; can't concentrate. Physiological signs present (e.g., nausea, sweating, fatigue, gastrointestinal distress) (9)
- Highest level of physical discomfort you have ever felt (10)

If you experience any physical or emotional discomfort due to your participation in the experiment, let a member of the research team know as soon as possible. While the research team will check in with all operators before and after each run, if you need to speak to someone about feelings of discomfort or distress, you are free to do so at any time. You are also free to take a break or stop your participation in the experiment at any time.

I have read and understand what to do if I am distressed. *

Please choose only one of the following:

- Yes
- No

Thank you for completing this survey. We have recorded your response!

B.4 Post-SIMEX Survey

Please complete the survey to the best of your abilities. If you have questions, request a member of the data collection team come assist you.

There are 24 questions in this survey.

B.4.1 Participant Demographics

Questions in this section are to collect information for the final report and contact information if we need to contact you during the experiment.

**Select the identity and position you have been assigned:*

Your unique identity is composed of an alphanumeric code, your role in the SIMEX, and your pseudonym or real name if you haven't been provided with a pseudonym.

B.4.2 Notes and Document Upload

Please upload or paste in your notes from the SIMEX during the week.

(Optional) Upload your SIMEX Journal to share your thoughts with the SIMEX team.

- [File Upload]

(Optional) Copy and paste content from your SIMEX journal into the free response text box.

- [Free Response]

B.4.3 Awareness of School Security

How strongly do you agree or disagree with the following statements regarding your awareness of school security?

Please choose the appropriate response for each item:

Figure B-7. Awareness of School Security Responses.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am aware of the procedures when there is an active shooter at a school.					
I am well informed on cases of active shooters in schools.					

B.4.4 Perception of Importance to School Security

Please rate how important you think the following are in preventing loss of life in active shooter situations:

** Please rate how important you think the following are in preventing loss of life in active shooter situations:*

Please choose the appropriate response for each item:

Figure B-8. Perception of Importance to School Security Responses.

	5 - Extremely Important	4 - Moderately Important	3 - Somewhat Important	2 - Slightly Important	1 - Not at all Important
School resource officers					
Armed school resource officers					
Armed school staff					
Ability to lock doors					
Policy of locked doors during classes					
Staff preparedness					
Student preparedness					
Early detection of shooter's intent					
Metal detectors					
Staff intervention with shooter					
Staff initiation of active shooter emergency protocol					
Student initiation of active shooter emergency protocol					
Panic buttons in classrooms					
Covering windows					
School layout					
Successfully isolating the shooter					
Using classroom blind spots					
Exterior barriers					
Limiting school access points					

B.4.5 Overall Feelings of Public High School Safety for Students/Faculty

School safety evaluation: Please choose the appropriate response for each item:

Figure B-9. Overall Feelings of Public High School Safety for Students/Faculty Responses.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel safe before and after school while on school grounds.					
I feel safe when I am in my classrooms.					
I feel safe in the school hallways.					
I feel that security procedures at my school are effective.					

Respond to these questions regarding your perception of school safety in the United States K-12 School Systems.

B.4.6 NASA TLX Weighting

This section is only for teachers, the admin, the SROs, and the red team.

Instructions: After each SIMEX run, you were asked to provide ratings (21pt scale) on your perceptions of workload in regard to: mental demand (mental activity), temporal demand (time pressure), performance (your success), effort (how hard you had to work), and frustration level (stress and discouragement). You will now be presented with a series of pairs of these five items. Your task is to choose which of these items was more important to your experience of workload in the SIMEX tasks. Please consider all of the SIMEX runs when making these choices.

Definitions:

- Mental Demand: How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?
- Temporal Demand: How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred?
- Performance: How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)?
- Effort: How hard did you have to work (mentally and physical) to accomplish your level of performance?
- Frustration Level: How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

* Of the two factors below, which one contributed more to the workload of the SIMEX? Please choose only one of the following:

- Mental demand
- Effort

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Temporal demand
- Mental demand

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Frustration
- Mental demand

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Performance
- Temporal demand

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Frustration
- Effort

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Temporal demand
- Effort

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Performance
- Frustration

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Temporal demand
- Frustration

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Performance
- Mental demand

* Of the two factors below, which one contributed more to the workload of the SIMEX? * Please choose only one of the following:

- Effort
- Performance

B.4.7 The SIMEX Experience

Answer the following questions about your experience in the SIMEX.

Describe your overall experience participating in this SIMEX.

- [Free Response]

What can we do to improve the SIMEX operations and experience for participants?

- [Free Response]

What is your favorite memory from the SIMEX?

- [Free Response]

B.4.8 Virtual Reality Feedback

Provide feedback on your experience using Virtual Reality (VR) in the experiment.

How strongly do you agree or disagree with the following statements? Please choose the appropriate response for each item:

Figure B-10. Virtual Reality Feedback Responses.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
The use of VR made the simulation feel realistic.						
It was beneficial to use VR given the role(s) that I played						
I did not feel any discomfort using VR, including but not limited to nausea, dizziness, sweating, pallor, vomiting, postural instability etc.						

We are actively working on improving the VR based capabilities to increase the level of realism. Do you have any suggestions as to what would make the simulation feel more realistic?

- [Free Response]

B.4.9 Level of Comfort with the Experiment

The Subjective Units of Discomfort Scale (SUDS) is a frequently used self-report measure which provides subjective information regarding an individual's level of discomfort and/or distress (Kim, Bae, & Park, 2008). Ratings on the one-item measure follow a 10-point scale to indicate levels of discomfort ranging from 0 = "no discomfort" to 10 = "highest discomfort ever felt." Ratings are intended to capture your level of comfort related to your participation in the experiment.

** Rate your level of comfort with the experiment:*

Please choose only one of the following:

- Totally comfortable with the experiment (1)
- Mostly comfortable with the experiment (2)
- Somewhat comfortable with the experiment (3)
- Mild discomfort with the experiment (4)
- Mild-to-moderate discomfort, some elements are bothersome (5)
- Moderate discomfort; concerned but will participate (6)
- Moderate-to-strong discomfort; have considered not participating (7)
- Strong discomfort; considering not participating (8)
- Extreme discomfort; signs of distress present when I think about participating (e.g., nausea, sweating, fatigue, headache) (9)
- Highest level of discomfort ever felt, I do not want to participate in the experiment (10)

If you experience any physical or emotional discomfort due to your participation in the experiment, let a member of the research team know as soon as possible. While the research team will check in with all operators before and after each run, if you need to speak to someone about feelings of discomfort or distress, you are free to do so at any time. You are also free to take a break or stop your participation in the experiment at any time.

** I have read and understand what to do if I am distressed.*

Please choose only one of the following:

- Yes
- No

Thank you for completing this survey.

APPENDIX C: RUN MATRIX

Figure C-1: Run Matrix.

Run#	Day	Time	Run Configuration	Run Type	SRO	Door Policy	Actions	Motive	Mission	Shooter Dest	SRO Start
1	Thursday	AM-1	C7-T	Experiment	Present	Unlocked	Limited	Targeted	D	108	East
2	Thursday	AM-2	C6-Max	Experiment	Present	Locked	Unlimited	Max Casualty	I	106	Cafeteria
3	Thursday	AM-3	W1	Wildcard	Present	Unlocked	Limited	Special	F	209	Sports
4	Thursday	PM-1	C8-Max	Experiment	Present	Unlocked	Unlimited	Max Casualty	G	106	Cafeteria
5	Thursday	PM-2	C5-T	Experiment	Present	Locked	Limited	Targeted	J	200	Main
6	Friday	AM-1	C8-T	Experiment	Present	Unlocked	Unlimited	Targeted	I	216	Sports
7	Friday	AM-2	C4-Max	Experiment	Absent	Unlocked	Unlimited	Max Casualty	E	108	
8	Friday	AM-3	C5-Max	Experiment	Present	Locked	Limited	Max Casualty	J	209	Main
9	Friday	PM-1	W4	Wildcard	Present	Unlocked	Unlimited	Special	C	216	Cafeteria
10	Friday	PM-2	C1-T	Experiment	Absent	Locked	Limited	Targeted	F	211	
11	Friday	PM-3	C2-Max	Experiment	Absent	Locked	Unlimited	Max Casualty	B	210	
12	Monday	AM-1	C6-T	Experiment	Present	Locked	Unlimited	Targeted	D	216	West
13	Monday	AM-2	W11	Wildcard	Present	Locked	Unlimited	Special	H	216	West
14	Monday	AM-3	C5-T	Experiment	Present	Locked	Limited	Targeted	H	106	Sports
15	Monday	PM-1	W2	Wildcard	Present	Unlocked	Unlimited	Special	I	210	Main
16	Monday	PM-2	C3-T	Experiment	Absent	Unlocked	Limited	Targeted	F	210	
17	Monday	PM-3	C1-Max	Experiment	Absent	Locked	Limited	Max Casualty	E	209	
18	Tuesday	AM-1	C3-Max	Experiment	Absent	Unlocked	Limited	Max Casualty	B	112	
19	Tuesday	AM-2	W9	Wildcard	Present	Locked	Unlimited	Special	H	112	Sports
20	Tuesday	AM-3	C4-T	Experiment	Absent	Unlocked	Unlimited	Targeted	J	200	
21	Tuesday	PM-1	C2-T	Experiment	Absent	Locked	Unlimited	Targeted	I	210	
22	Tuesday	PM-2	W8	Wildcard	Present	Unlocked	Limited	Special	C	108,211,209	Sports
23	Tuesday	PM-3	C1-T	Experiment	Absent	Locked	Limited	Targeted	A	109	
24	Wednesday	AM-1	C8-T	Experiment	Present	Unlocked	Unlimited	Targeted	C	109	East
25	Wednesday	AM-2	C2-Max	Experiment	Absent	Locked	Unlimited	Max Casualty	B	210	
26	Wednesday	AM-3	W12	Wildcard	Present	Locked	Unlimited	Max Casualty	G	216	West
27	Wednesday	PM-1	C3-T	Experiment	Absent	Unlocked	Limited	Targeted	A	202	
28	Wednesday	PM-2	C6-T	Experiment	Present	Locked	Unlimited	Targeted	G	211	Main
29	Wednesday	PM-3	C4-T	Experiment	Absent	Unlocked	Unlimited	Targeted	H	112	
30	Thursday	AM-1	C3-T	Experiment	Absent	Unlocked	Limited	Targeted	F	108	
31	Thursday	AM-2	C8-T	Experiment	Present	Unlocked	Unlimited	Targeted	C	109	East
32	Thursday	AM-3	C2-T	Experiment	Absent	Locked	Unlimited	Targeted	A	209	
33	Thursday	PM-1	C4-T	Experiment	Absent	Unlocked	Unlimited	Targeted	J	109	
34	Thursday	PM-2	C7-Max	Experiment	Present	Unlocked	Limited	Max Casualty	A	112	Sports
35	Thursday	PM-3	C7-T	Experiment	Present	Unlocked	Limited	Targeted	B	202	East
36	Thursday	PM-4	C3-T	Experiment	Absent	Unlocked	Limited	Targeted	G	108	
37	Friday	AM-1	W15	Wildcard	Present	Locked	Unlimited	Special	E	211	Main
38	Friday	AM-2	W10	Wildcard	Present	Locked	Limited	Max Casualty	J	209	Main
39	Friday	AM-3	W5	Wildcard	Present	Unlocked	Unlimited	Max Casualty	G	106	Cafeteria

APPENDIX D: SAMPLE STUDENT MISSION SHEET

Figure D-1: Sample Student Mission Sheet

Your homeroom is Classroom 216 (Teal).	
-- Mission A -- 1. Go to Red hallway (136E). 2. Go to Classroom 200 (Purple). 3. Go to Classroom 216 (Teal).	-- Mission B -- 1. Go to Classroom 209 (Green). 2. Go to Purple Hallway (232E). 3. Go to Classroom 216 (Teal).
-- Mission C -- 1. Go to Red bathroom (141 or 142). 2. Go to Classroom 200 (Purple). 3. Go to Classroom 216 (Teal).	-- Mission D -- 1. Go to Classroom 200 (Purple). 2. Go to a Teal bathroom (243 or 244). 3. Go to Classroom 216 (Teal).
-- Mission E -- 1. Go to Library 103 (Black). 2. Go to Black Hallway West Entrance (132W). 3. Go to Classroom 216 (Teal).	-- Mission F -- 1. Go to Red Stairwell (121). 2. Go to Classroom 209 (Green). 3. Go to Classroom 216 (Teal).
-- Mission G -- 1. Go to Library 103 (Black). 2. Go to Cafeteria 100 (Black). 3. Go to Classroom 216 (Teal).	-- Mission H -- 1. Go to Blue Stairwell (123). 2. Go to Blue Hallway (131). 3. Go to Classroom 216 (Teal).
-- Mission I -- 1. Go to Purple Hallway (232W). 2. Go to Green bathroom (242 or 243). 3. Go to Classroom 216 (Teal).	-- Mission J -- 1. Go to Blue Hallway (131). 2. Go to Classroom 211 (Teal). 3. Go to Classroom 216 (Teal).

APPENDIX E: SAMPLE TEACHER MISSION SHEET

Figure E-1: Sample Teacher Mission Sheet

Your homeroom is Classroom 108 (color: Blue).	
-- Starting Location A -- Go to Admin 104	-- Starting Location B -- Go to Homeroom
-- Starting Location C -- Go to Caf 100	-- Starting Location D -- Go to Homeroom
-- Starting Location E -- Go to Homeroom	-- Starting Location F -- Go to Admin 104
-- Starting Location G -- Go to Homeroom	-- Starting Location H -- Go to Caf 100
-- Starting Location I -- Go to Homeroom	-- Starting Location J -- Go to Homeroom

APPENDIX F: SAMPLE DAILY SCHEDULE

Figure F-1: Sample Daily Schedule

Time of Day	Delta	MITRE	Operators
8:00	0:30	MITRE Sync + Start of Day Checklist	N/A
8:30	0:20	Monitor Arrival	AM Baseline
8:50	0:10	Pre-Run Checklist	
9:00	0:15	Morning Announcements + Pre-Run Checklist	Seated for Pre-Run Checklist
9:15	0:10	*** Execute Run **	<-
9:25	0:12	Survey + Small Group Hotwash	<-
9:37	0:07	Group Hotwash	<-
9:45	*0:15*	*BREAK*	*BREAK*
10:00	0:05	Pre-Run Checklist	*BREAK*
10:05	0:10	Pre-Run Checklist	Seated for Pre-Run Checklist
10:15	0:10	*** Execute Run **	<-
10:25	0:12	Survey + Small Group Hotwash	<-
10:37	0:07	Group Hotwash	<-
10:45	*0:15*	*BREAK*	*BREAK*
11:00	0:05	Pre-Run Checklist	*BREAK*
11:05	0:10	Pre-Run Checklist	Seated for Pre-Run Checklist
11:15	0:10	*** Execute Run **	<-
11:25	0:12	Survey + Small Group Hotwash	<-
11:37	0:07	Group Hotwash	<-
11:45	0:15	MITRE Sync	*BREAK (Lunch)*
12:00	*0:50*	*BREAK for Lunch*	*BREAK (Lunch)*
12:50	0:05	Pre-Run Checklist	*BREAK (Lunch)*
12:55	0:10	Pre-Run Checklist	Seated for Pre-Run Checklist

Figure F-2: Sample Daily Schedule (Cont.)

13:05	0:10	*** Execute Run **	<-
13:15	0:12	Survey + Small Group Hotwash	<-
13:27	0:07	Group Hotwash	<-
13:35	*0:15*	*BREAK*	*BREAK*
13:50	0:05	Pre-Run Checklist	*BREAK*
13:55	0:10	Pre-Run Checklist	Seated for Pre-Run Checklist
14:05	0:10	*** Execute Run **	<-
14:15	0:12	Survey + Small Group Hotwash	<-
14:27	0:07	Group Hotwash	<-
14:35	*0:15*	*BREAK*	*BREAK*
14:50	0:05	Pre-Run Checklist	*BREAK*
14:55	0:10	Pre-Run Checklist	Seated for Pre-Run Checklist
15:05	0:10	*** Execute Run **	<-
15:15	0:12	Survey + Small Group Hotwash	<-
15:27	0:07	Group Hotwash	<-
15:35	0:05	Closing Announcements	
15:40	*0:20*	*BREAK*	*Operators Leave*
16:00	0:30	MITRE Sync	N/A

APPENDIX G: DATA SUMMARY TABLE

Table G-1 presents the factors and calculated metric values for each of the 24 record runs. The metrics follow the order described in Section 2.4. The last three metrics were included for additional insights during analysis and are described in Section 3.

As described in Section 2.3, 16 runs were randomly selected out of the full 24 in order to have a balanced dataset when determining the effects of the shooter mission. These 16 runs are marked in the first column of the table. For the other factors, all 24 runs were considered.

Table G-1. Summary of Data Used in the Analysis.

2^4	Run#	M1: SART (mean)	M2: TLX (mean)	M3: SUDS (mean during)	M4: Casualties (pct)	M5: Safe (pct)	M6: Time to Broadcast (secs)	M7: Average time to class lockdown (secs)	M8: Time to end (mins)	M401: Shots Fired	M402: Shots per minute	M501: Number of classes in lockdown
	1	19.90625	90.09090909	2.533333333	0.307692308	20.25316456	27	36.10118	4.066666667	2	1.627748	6
X	2	21.66666667	77.90909091	2.258064516	9.174311927	27.89968652	33	129.0082	5.333333333	91	54.76979	4
X	4	19.40625	60.63636364	2.366666667	14.89361702	19.6875	11	35.0693	2.916666667	94	38.14465	3
	5	18.0625	84.72727273	2.4	2.44648318	33.85579937	54	-24.1648	0.416666667	13	2.334546	6
	6	21.4375	92.15384615	2.766666667	13.67781155	38.75	30	52.57128	7	70	9.765807	7
X	7	20.29032258	103.5833333	2.7	13.45565749	16.66666667	19	-10.5713	1.416666667	66	59.41248	3
X	8	19.3125	92.76923077	2.7	18.90243902	33.85579937	21	-50.2972	2.933333333	98	39.69888	5
X	10	17.93548387	81.41666667	2.666666667	7.384615385	19.81132075	37	-26.8277	7	92	46.2327	5
X	12	20.03125	80.92307692	2.4	2.43902439	15.98746082	77	10.4005	4.25	12	6.586918	2
X	14	21.0625	88.61538462	2.666666667	13.7195122	31.97492163	28	-99.8345	2	100	61.99884	7
	16	19.16129032	85.16666667	2.7	17.3374613	6.329113924	45	18.13069	3.05	91	34.67086	0
X	17	19.48387097	108	3.066666667	12.80487805	24.45141066	20	-83.2682	1.25	96	65.68669	3
X	18	18.5	116.3333333	3.172413793	14.24148607	17.14285714	96	17.18299	2.516666667	81	43.98222	2
X	21	21.13333333	77.41666667	2.689655172	7.055214724	27.12933754	19	-7.86554	3.366666667	48	21.852	4
	23	21.83870968	113.25	2.666666667	7.272727273	24.6875	22	-137.093	0.233333333	61	39.9983	4
X	25	19.4516129	88	2.8	17.37804878	20.37617555	42	-119.096	3.516666667	95	27.34348	4
X	27	18.32258065	105.75	2.9	12.80487805	11.91222571	19	33.70104	0.833333333	76	51.57842	2
	28	17.625	107.1538462	2.9	0.911854103	24.375	15	-71.418	1.216666667	4	21.14518	7
X	29	16.84375	105.75	2.741935484	12.5382263	2.1875	22	-87.4735	0.883333333	86	33.95801	0
X	31	20.09375	120.3333333	2.866666667	3.636363636	17.5	22	14.06276	2.65	39	19.29575	3
	32	19.0625	101	3.032258065	20.66869301	27.8125	20	-37.0449	3.416666667	96	37.25647	5
	33	19.40625	109	2.774193548	18.29268293	19.0625	22	18.76605	4.183333333	90	24.62159	1
X	34	18.53125	109.9230769	3.033333333	6.96969697	27.1875	16	18.26896	7	33	52.72774	4
X	35	19.71875	99.69230769	2.566666667	0.303951368	23.125	12	38.24077	5.3	1	0.780808	3

APPENDIX H: HOMELAND SECURITY SYSTEMS ENGINEERING & DEVELOPMENT INSTITUTE OVERVIEW

The Homeland Security Systems Engineering & Development Institute (HSSEDI) is a federally funded research and development center (FFRDC) established by the Secretary of Homeland Security under Section 305 of the Homeland Security Act of 2002. The MITRE Corporation operates HSSEDI under the Department of Homeland Security (DHS) contract number 70RSAT20D00000001.

HSSEDI's mission is to assist the Secretary of Homeland Security, the Under Secretary for Science and Technology, and the DHS operating elements in addressing national homeland security system development issues where technical and systems engineering expertise is required. HSSEDI also consults with other government agencies, nongovernmental organizations, institutions of higher education, and nonprofit organizations. HSSEDI delivers independent and objective analyses and advice to support systems development, decision making, alternative approaches, and new insight into significant acquisition issues. HSSEDI's research is undertaken by mutual consent with DHS and is organized by tasks.

This report presents the results of Simulation Experiment (SIMEX) 20-6 (School Security) execution and data analysis conducted under HSSEDI Task # 70RCSA19FR0000023. The purpose of the task was to conduct a SIMEX that will 1) examine and evolve school security policies; 2) develop concepts of operation and tactics for school security operations; and 3) examine current and proposed school security technologies and configurations.

The information presented in this report does not necessarily reflect official DHS opinion or policy.

APPENDIX I: SIMEX TECHNICAL ARCHITECTURE

I.1 Technical Architecture

The SIMEX utilized virtual private networking and remote conferencing to connect participants in eight locations on the MITRE McLean campus to a distributed environment curated by an experiment support team primarily based from home stations. VR-enabled client workstations were connected via a distributed local area network to on-campus hosts and data recording equipment to fully distribute the VR environment to all on-campus locations. The experiment was executed by a minimum on-site crew composed of MITRE, sponsor, and GMU research staff.

The SIMEX 20-6 technical architecture was composed of four main pieces to drive the experiment: simulation clients, a simulation server, a set of networking layers to accommodate the distributed participant locations, and the data collection components. The simulation environment included the school model and surrounding terrain, and the avatars that allowed participants to interact in a realistic virtual world. The distributed layer provided the functionality necessary to keep operators and experimenters safely distributed during the SIMEX, in accordance with MITRE's COVID-19 protocols. Finally, data collection components enabled experimenters to gather experiment observations from the system.

I.1.1 Network Architecture

Most of the participants were connected over a single network spanning the SEAL facility (consisting of the observation deck, main command center floor, developer lab, and dismount room). In order to accommodate MITRE's COVID-19 restrictions, additional participants were housed elsewhere in the building (the Agile Capability Mashup Environment lab and Charles S. Robb Auditorium) and connected via MITRE's Networked Experimentation, Research, and Virtualization Environment. All rooms and select participant systems were also connected via Microsoft Teams to enable communications with the experiment control team, screensharing with data collection, and briefings to visitors, in-person or remote. Additionally, Microsoft Teams and remote desktop were used for debugging and technical issue resolution to minimize close-proximity contact between the technical staff and experiment participants. Figure I-1 illustrates the distributed architecture of the SIMEX and Figure I-2 illustrates how the various rooms and participants were connected using Microsoft Teams.

Figure I-1. The Network Configuration During SIMEX 20-6 Distributed Operations.

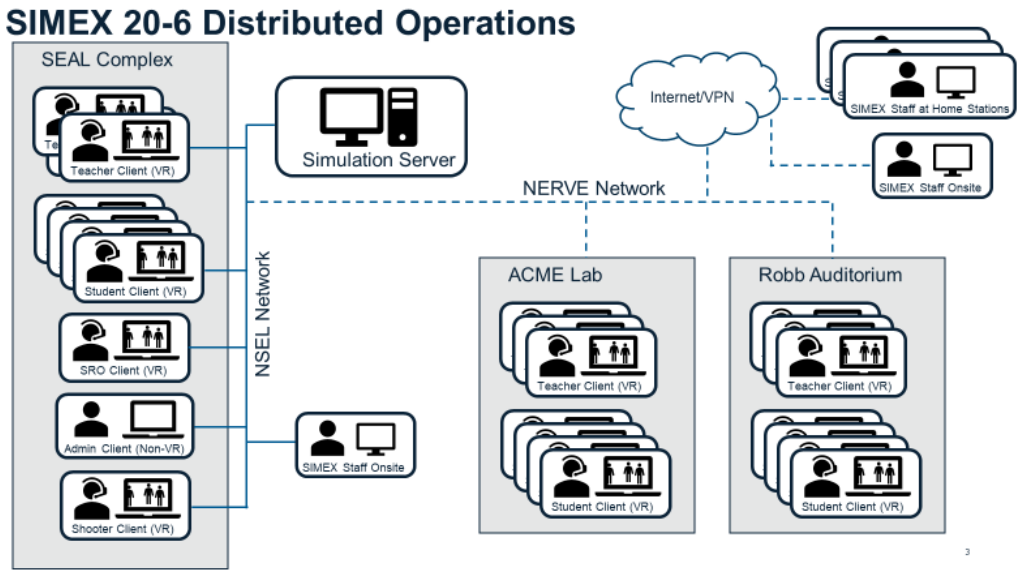
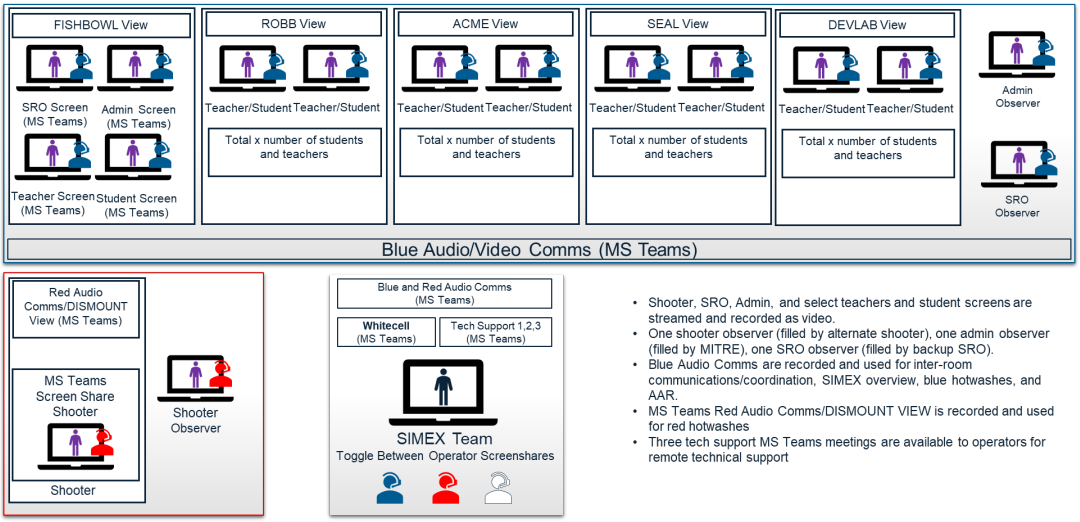


Figure I-2. Mapping of Physical Rooms and Participants to Microsoft Teams Channels.



The VR architecture consisted of a single server and multiple client systems tailored for each individual participant role. The server acted as the central coordinator and tracked shared environmental state information for the entire simulated environment. The server also controlled the motion of all the NPC students, tracked (and synchronized) the state of all environmental variables, such as the states of doors (locked or unlocked, open or closed), and computed and tracked the state of the various player and non-player entities (synchronized locations and shot state). Both the server and client applications were built in the Unity3D game development engine.

I.1.2 Client Systems

The client applications provided the user interface for all participants in the experiment. Each role activated a different version of the VR environment when setting up for a run. All participants except the school administrator were immersed in a 3D VR environment with the use of the Oculus Rift VR headset. This environment allowed participants to move around and view their environment as though wholly immersed in the virtual world. The Oculus Rift hand controllers were used to provide movement of player avatars and to allow participants to interact with aspects of the virtual environment, such as doors. The capabilities of the different versions are summarized in Table I-1, followed by screenshots in Figure I-3 and Figure I-4.

Table I-1. Mapping of Operator Roles to Systems.

Operator System	Capabilities
VR Student Client	Navigation around the school environment and audio from nearby avatars in the environment.
VR Teacher Client	Navigation around the school environment and audio from nearby avatars in the environment; door locking; radio communications with the admin; PA communications.
VR SRO Client	Navigation around the school environment and audio from nearby avatars in the environment; radio communications with the admin; drawing and discharging weapon.
VR Shooter Client	Navigation around the school environment and audio from nearby avatars in the environment; drawing and discharging weapon. The shooter operator perceived all characters in the simulation as zombies for psychological safety reasons.
Administrator Client	Radio communications with each teacher and the SRO; PA communications. The administrator client was unique in that it was just a desktop interface with no VR component.

Figure I-3. VR Applications for the Shooter (top left), SRO (top right), Teacher (bottom left), and Student (bottom right).

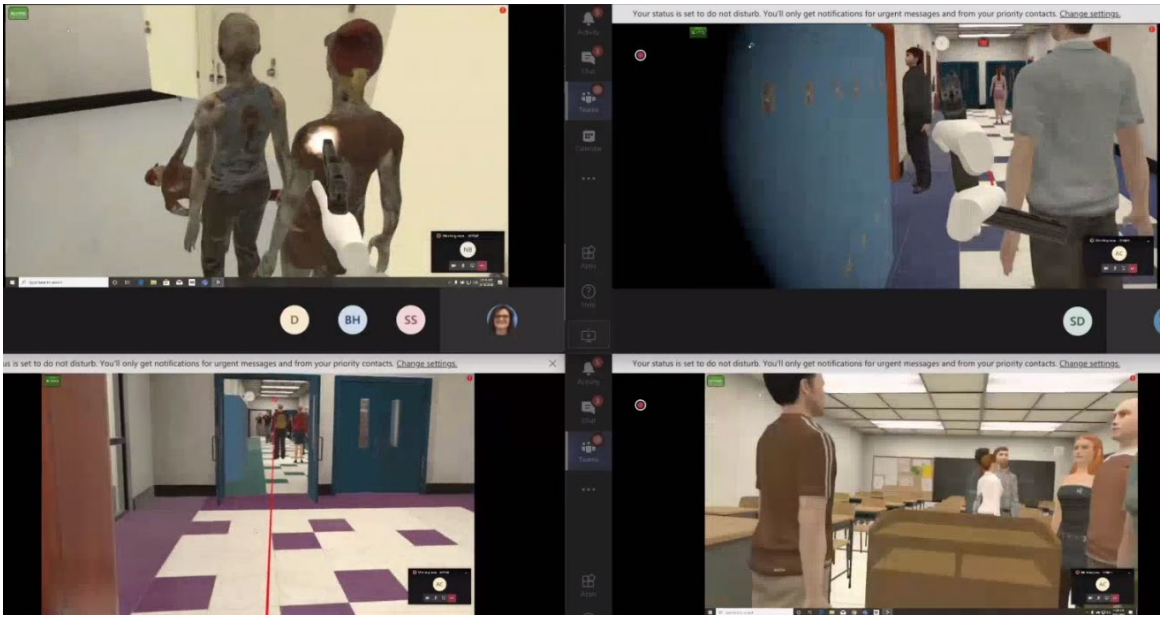


Figure I-4. Desktop Application for the Administrator.

I.1.2.1 Student VR Client

All students had the ability to move and look around the virtual environment using the VR headset and hand controllers. They also had the ability to manipulate doors by bringing their virtual hand to the door knob or handle, toggling the state between opened and closed provided the door was unlocked. Communication between students and with other participants took place through "proximity chat," allowing characters in the environment to speak and be heard within a limited region around their character location (and attenuated with distance). This limited verbal communications to the immediate vicinity, typically within the same room or region of the hallway.

I.1.2.2 Teacher VR Client

Participants serving as teachers in the VR environment had the same basic movement, interaction, and communication capabilities as the student players, with several important additions. Teachers had the ability to lock doors by holding their hand against an emulated keypad lock for a required duration of 3 to 6 seconds (emulating the time to operate a conventional keyed lock). Teachers also had emulated radio communications to the front office and access to the school PA system when allowed by administrative policy (both activated via button presses on a participant's hand controllers).

I.1.2.3 SRO VR Client

The SRO VR client had basic movement and environment interaction, similar to the student client, with the addition of a firearm and access to radio communications with the administrator. The firearm was located in the SRO player menu and retrieved by grabbing the object with the VR hand controller. The gun was fired using the trigger on the hand controller holding the weapon.

I.1.2.4 Shooter VR Client

The shooter VR client had basic movement and environment interaction, similar to the student client, with the addition of a firearm (a handgun holding 15 rounds and 5 spare magazines, each also holding 15 rounds). To operate the handgun, the shooter opened the inventory menu, manually selected the handgun, and held it in the game environment while firing. Hits were determined by ray casting from the gun barrel with probabilistic determination of fatality for targets that were hit. As with every other student, the shooter had proximity chat for communications. In the shooter environment, all avatars appeared as zombies.

I.1.2.5 Admin VR Client

The admin client was not in VR, instead it was a simple 2D interface with buttons to toggle the various lines of communication afforded the admin. This allowed the admin to select whether to hear or speak to the various teacher participants and the SRO over the emulated radio, in any combination. The admin also had a toggle for speaking over the PA.

APPENDIX J: EXPLORATORY ANALYSIS OF SURVEY FEEDBACK

J.1 Exploratory Analysis of Survey Feedback

Subjective data within the post-run and post-SIMEX surveys were analyzed for explicit and implicit themes and sub-themes based on participant role and experimental factors. More information on this exploratory analysis of survey feedback can be found in

The analysis included 486 post-run survey responses from operators who were asked to briefly describe what happened during the run and to document if anything unexpected occurred during the run. Twenty-four operators submitted journal entries in the post-SIMEX survey to record additional thoughts, feeling, or actions experienced during SIMEX. Major themes and sub-themes were coded based on role and factor. While these findings cannot be generalized outside of the SIMEX experiment, emergent themes do provide additional insight for quantitative results.

J.1.1 Emergent Themes by Role

Emergent themes based on role highlighted the critical nature of situational awareness, student safety, and how being close to a threat changed operator behavior (see Table J-1). Active threat stimuli (e.g., gun shots, dead bodies, or seeing the SRO neutralized) prompted stress responses and behavioral changes in teachers and students. From the shooter's point of view, the SRO, teachers, and communications were constant threat stimuli and similar variations in behavior emerged. Threat proximity resulted in more rigid adherence to lockdown protocols for teachers and behavioral and strategic variations for the shooter. SRO presence was universally comforting to students and teachers and, not surprisingly, a substantial threat to the shooter. Both the admin and the SRO closely followed protocols, only noting instances in which communications were limited or confusing and instances where situational awareness was low. In all runs, both the admin and the SRO used neutral and prescriptive language, rarely deviating from protocols.

Of significance was the shooter's persistent focus on eliminating the SRO. The shooter implied that the SRO must be neutralized in order to proceed with the intended mission. Other salient stressors that emerged for the shooter included hearing information regarding his own location or description, interacting with teachers who could reveal his location, and anything which modified his intended plan. The shooter would frequently attempt to 'blend in' as a student or hide in order to locate his target or the SRO.

Table J-1. Emergent Themes Based on Role.

Teachers	Students	Shooter	SRO	Admin
Major Themes				
Student Safety	Safety Context	Strategic Awareness	Situational Awareness	Communication
Sub-Themes				
Responsibility	Teacher Presence	Constant Planning	Low SA Threat	Communication Protocol
Threat Proximity	Safety Protocol	SRO Target	SRO Presence	Confusion Impact
Student Noncompliance	Threat Proximity	Communication Behavior		
Student Emotion		Teacher Threat		

J.1.1.1 Teachers

Teachers reported great concern for the physical safety and personal wellbeing of students. Teachers took risks to keep students safe (e.g., standing in the hall to bring students into a locked classroom). Teachers indicated fear when the shooter was in close proximity or when they witnessed a death. When students did not comply with lockdown protocols teachers became frustrated. Teachers reported less fear when the SRO was present and were more likely to attend to student safety responsibilities when the SRO was present, given they were less concerned about their own personal safety. To manage stress and ensure compliance, teachers used classroom management techniques, such as playing games with students or singing with students.

Table J-2. Teachers Major Theme: Student Safety.

Teachers Major Theme: Student Safety
Responsibility: Ensuring student safety was a top priority for teachers, even if doing so put the teacher in danger.
• "There's a lot more responsibility as a teacher … and it was extremely stressful." • "I locked the doors and pointed them [students] to hide at the corner. I stayed with them, told them I will try my best to keep them safe. I won't give them up, I'll never run around and desert them." • "I decided to find any lost students hoping to avoid the shooter. Unfortunately, the shooter got me." • "I would periodically tell the students to get to the back of the class and open the door to check and see if anyone is stuck in the hall or if the shooter is in the area."
Threat Proximity: Teachers indicated stress/fear when they were in the proximity of the shooter or when they perceived danger. Conversely, when teachers reported being shot, they often used neutral language. Threat proximity was reported more frequently in runs where the SRO was not present and during mass casualty runs.
• "I feel more stressed about having to quickly act (lock doors, gather students, make announcement, etc.) when I see the shooter or when I see dead bodies." • "The fear that hit me with the possibility that the shooter might've been outside my room was slightly paralyzing." • "It's terrible watching people die in front of you, that was definitely the most frustrated and high anxiety I have felt." • "I saw the gun and I was shot. Happened pretty early on as well."
Student Non-compliance: Teachers were considerably more stressed when students misbehaved or did not follow lockdown protocols.
• "There was one student that was refusing to head into lockdown. I had to yell at him for being obnoxious, I waited for him in good conscience and eventually he complied and went with us. But still, it almost jeopardized our lives due to one's foolishness." • "I feel bad because I'm not sure if [my student misbehaving] caused the SRO to be farther from where [the SRO] was supposed to be."
Student Emotion: Teachers were attentive to student expressions of stress or fear.
• "The three of us played games as a way to distract them from what was happening." • "I sang 'Auld Lang Syne' to them as a mean of comfort and reassurance that we're going to get through this together in one collective goal of survival."

J.1.1.2 Students

Student surroundings and environment were important elements affecting student's sense of safety. If teachers or the SRO were present, the students were relaxed. If students were not inside a locked classroom (e.g., stuck in the hall or bathroom) or if they experienced auditory or visual stimuli (e.g., shots fired or seeing dead bodies) they reported being more afraid. Students universally felt more comfortable in the presence of a teacher or the SRO, regardless of their surroundings.

Table J-3. Students Major Theme: Student Context.

Students Major Theme: Student Context
Teacher Presence: Students indicated increased comfort with teachers and would seek safety in a classroom with a teacher.
• "Eventually, I found a teacher who let me into her room…Thankfully, we were all safe and stayed in the back of the room." • "Everything ran smoothly and the teacher communicated to us everything that was being said over the radio." • "I decided to try and find a classroom that hadn't been locked…I got to a room I'd been to many times and knew the teacher in and begged to be let in. She did after asking my name and I stayed there for the rest of the run."
Safety Protocol: Students felt unsafe when routine protocols were not in place, such as being in a locked classroom without a teacher/in an unfamiliar room, or if protocols were ineffective (e.g., shot in their homeroom).
• "I thought I was safe in my homeroom, but what just happened to me was out of nowhere." • "Thankfully, we were all safe and stayed in the back of the room. I still felt a bit anxious about being in a classroom because…I wasn't sure whether I was safe." • "I was in the cafeteria, but didn't feel safe there or outside."
Threat Proximity: Students conveyed a heightened level of stress when they saw the shooter, heard shots, saw bodies, or got shot. When in close proximity to the shooter, students reported being stressed/afraid.
• "Suddenly, a female student in front of me got shot, I gasped out of shock (it just happened out of nowhere), and then I got shot. The worst part is, I saw the students in my classroom, yet I could not remember any description of the shooter due to shock." • "The teacher made it back, but was distressed that there were so many bodies in the hall." • "Our teacher wasn't in homeroom, so we tried to run to the teacher we hid with before. But unfortunately, that was where the shooting started. I literally followed the shooter in, I was running on instinct."

J.1.1.3 Shooter

The shooter constantly had a predetermined plan, even beyond the assigned mission. When the shooter did not have enough information to execute the plan or when the plan had to change, he became stressed. The shooter conveyed a persistent need for accurate information to control the situation, and without high levels of situational awareness he experienced emotional stress and behavioral changes. In runs with the SRO present, the shooter focused on eliminating the SRO. The shooter utilized communications to supplement planning, became agitated when communications were inaccurate, and saw teachers as a viable threat to be eliminated.

Table J-4. Shooter Major Theme: Strategic Awareness.

Shooter Major Theme: Strategic Awareness
Constant Planning: Following every run, the shooter commented on the 'plan' and expressed frustration when the plan had to be modified or was unsuccessful.
• "I went to room 211 and scouted out the location." • "I walked around in order to waste time in the beginning of the run. Then I looped around the blue hallway twice, once to scout and once to initiate my plan." • "I was really mad at myself because I had told myself in the beginning that my character was not going to shoot anyone even if it all went wrong." • "Literally every part of my plan was bad from the word go."
SRO Target: The shooter actively sought out the SRO and was fixated on this for plan execution. The shooter often referenced risk avoidance and inferred that he could not fully proceed until the SRO was neutralized. The shooter often utilized hiding or attempts to look like a regular student to target the SRO.
• "I heard the SRO checking on rooms 215 and 216 and I thought that I could get the jump on [the SRO]." • "…decided that I should backtrack upstairs to throw the SRO off my trail." • "I saw the SRO come down the stairway, following the trail I had left…" • "I also opened a bunch of the main entrance doors in hopes to distract [the SRO] who I know is fond of making [sure] all the doors are shut." • "I knew I had to pretend to be someone else to have any chance so I complied with instructions and then [the SRO] concluded that I was not the shooter…I turned around, equipped my gun, and shot the SRO in the back."
Communication Behavior: When the shooter had to speak directly to the SRO or heard the admin/teachers talking about the shooter, he became agitated and behavioral modifications occurred. The shooter consistently utilized communications, either heard in person or over the PA, to adapt his behavior or strategy. Hiding or 'blending in' as another student was the most common strategy.
• "I started checking windows because I wanted to know where the people describing me were but could not find anyone. I then left the building." • "My movements were being broadcast through the school so I made my way to the black hallway and shot people there because I knew that no classrooms were around." • "Then I made my way over to room 109 to prevent the call about my location from being sent out." • "After trying to fake my way into a room, I decided it was best to hide as I started to hear my movements being discussed."
Teacher Threat: The shooter became stressed when in close proximity to teachers, citing their ability to communicate the shooter's location/description to the admin or SRO. Teacher threat was less persistent than the SRO because the shooter could eliminate nearby teachers. Threat mitigation included hiding or blending in, unless shots had been fired or a teacher was the target.
• "Next, I started to close the door but the teacher said, "we can't shut that yet to which I feigned innocence and said I didn't mean it." • "Shot teacher [pseudonym removed] because he was staring at me and I thought he would give away my movements." • "Not looking to blow my cover I went into that room and crouched in the corner."

J.1.1.4 SRO

Situational awareness regarding the shooter and student/teacher safety was a top priority for the SRO. This included identifying the location and description of the shooter, securing the school, and ensuring that students and teachers were physically and emotionally safe.

Table J-5. SRO Major Theme: Situational Awareness.

SRO Major Theme: Situational Awareness
Low SA Threat: Similar to the admin, the SRO used neutral, prescriptive language, indicating that adherence to protocol took precedence. The SRO only deviated from prescriptive notes regarding the run when information about the shooter was minimal. The SRO often noted that a lack of SA put the SRO and others at considerable risk.
• "Encountered shooter in hallway after teacher 7 stated he was in the purple hallway, got shot. • "Observed male matching description of shooter outside by house, gave commands to subject, could not tell if he had anything in his hands, and was then shot." • "Confusion on the school radio as to what is going on and where the shooter is…realistic in the sense that critical incident communication will always be a huge problem."
SRO Presence: The SRO was aware that his presence promoted a sense of safety and security for teachers and students. The SRO noted teachers and students felt safe when he came around to check on them during lockdown. This theme is also supported by the teacher and student reports of the SRO being present.
• "I was talking to unlocked rooms as I passed them." • "I spoke to students in rooms 209 + 210 and they advised they were ok."

J.1.1.5 Administrator

The admin used neutral, prescriptive language, indicating that adherence to protocol and establishing reliable and accurate communication took precedence. The admin noted incomplete attempts to receive or deliver information, when protocols were not followed, or when information was unclear or inaccurate. When situational awareness was low, reports of confusion and misinformation were common.

Table J-6. Admin Major Theme: Communications.

Admin Major Theme: Communications
Communication Protocol: Adherence to communication protocols for receiving or delivering information was a top priority for the admin.
• "Admin made announcement of lockdown. Admin asked teachers for location. T[eacher] 4 responded they saw dead students in the blue hallway. Admin checked in with teachers periodically. All but T[eacher] 2, T[eacher] 3, T[eacher] 4 and T[eacher] 7 responded." • "Unknown teacher called in with a location of the shooter but no description. Admin placed the school in lockdown."
Confusion Impact: The admin deviated from prescriptive reports when information was missing, teachers did not respond, or information relayed was inaccurate or abstruse.
• "Three teachers called the information in, could not hear all of them over each other." • "T[eacher] 8 reported that she was being taken hostage but did not provide a location. Admin called for T[eacher] 8 to get a location did not receive a response." • "Admin repeatedly called teachers for updates, individually and collectively, and received no responses except for T[eacher] 10. An unknown teacher did call in and said a student reported that shooter was in 108 but she was unsure."

J.1.2 Emergent Themes by Factor

Emergent themes by experimental factors and shooter mission aligned with themes by role as shown in Table J-7 and J-8. Stark contrasts were evident in reports of stress and fear related to SRO presence. When present, the SRO was a source of comfort and safety and teachers focused less on personal safety and more on student safety. Manual doors were universally frustrating for teachers and while centralized communications were more precise and efficient, teachers felt communications were clearer when announcements and updates were distributed. Mass casualty runs produced higher levels of emotional stress, presented significant communication challenges, and resulted in lower situational awareness for all operators. Targeted runs, while longer, revealed stronger adherence to lockdown protocols and better attempts to ensure students were safe.

Table J-7. Emergent Themes Based on Factor.

Presence of SRO		Door-Locking Policy	
Present	Absent	Automatic	Manual
Themes			
Impact	Stress	Lack of Control	Danger
Death of SRO	Increased Stress	Safer	Attempts Unsuccessful
Responsibility Shift		Locked Out	Time Constrains
Increased Safety			Frustration

Table J-8. Emergent Themes Based on Factor (Cont.).

Lockdown Notification Policy		Shooter Mission	
Centralized	Decentralized	Mass Casualty	Targeted
Themes			
Dependence	Protocol	Situational Awareness	Environmental Safety
Reduce Stress	Time Management	Threat Proximity	Protocol Adherence
Clarity Promotes Safety	Clear Communications	Lower SA	Student Safety
Inaccuracy Impacts Safety		Communication Challenges	
		Increased Visual Stimuli	

J.1.2.1 Presence of SRO

When the SRO was present, participants were more relaxed. When the SRO directly interacted with teachers and students, they felt comforted. When the SRO was seen by operators, responsibility for school safety shifted to the SRO, but teachers focused less on their own personal safety and more on student safety. When the SRO was shot, participants became more rigid about protocols and reported fewer attempts to escape outside. In runs without the SRO, participants indicated more stress and fear.

Table J-9. SRO Present Major Theme: Impact.

SRO Present Major Theme: Impact
Death of SRO: Reports of the SRO being shot were significant. Unlike seeing dead bodies, knowledge of the SRO being shot was linked to participants staying in lockdown and an increased sense of responsibility for school safety.
• "As the SRO was checking the cafeteria and… was about to leave the shooter was in the hall and shot the SRO down. So I continued hiding in the cafeteria communicating with admin." • "I called the shots to admin, then hid in my classroom for a couple minutes. Then I peeked my head out to look for the shooter…I could see the SRO's body on the floor." • "Heard shots, locked and closed door, went to back corner of room. Could tell SRO was shot."
Responsibility Shift: When the SRO was present, teachers and students were more apt to focus on their classrooms, protocols, and the SRO for information and reassurance. Once the SRO was seen, teachers took less risks regarding student safety and more closely adhered to lockdown protocols.
• "I keep it open for a few more seconds for students that still needed a room to be in. I went inside when I saw the SRO pass by." • "I locked the door, saw the SRO, and then closed it." • "I also felt more safe [sic] when there's a SRO present, because if you're in danger the SRO officer is on school premises and can get there in time."
Increased Safety: Similar to transferring control of school safety to the SRO, interactions with the SRO increased participant's sense of safety. Teachers were notably more relaxed when the SRO was present.
• "The SRO was right outside of my room, so I felt pretty safe." • "The SRO came in, tried to diffuse the situation and I survived." • "It was definitely one of my most anxiety inducing runs…felt safe with the SRO there, plus hearing [the SRO] negotiate with the shooter helped ease some anxiety." • "I feel safer when the SRO speaks to us from outside the room to check in."

Table J-10. SRO Absent Major Theme: Stress.

SRO Absent Major Theme: Stress
Increased Stress: Absence of the SRO was unsettling and perceived as more dangerous for students and teachers.
• "P.S. the runs with no SRO and manual locks, are the WORSE runs." • "When there's no SRO, you kind of feel screwed, because there's nobody there to help you at that exact moment."

J.1.2.2 Door-Locking Policy

Participants preferred automatic locks and reported a preference for having less responsibility for securing the door. Reports indicated that the less control and power teachers had to secure their classroom, the safer they felt. The downside was teachers and students getting locked out of rooms, which was frustrating and fear inducing. When manual locks were used, participants noted numerous challenges, highlighting difficulties in locking doors, locks taking too long to initiate, frustrations regarding locks, and being locked out of the classroom. Time management was also a concern, as teachers noted they were unsure whether they should secure the classroom or initiate communications.

Table J-11. SRO Present Major Theme: Impact.

SRO Present Major Theme: Impact
Safer: Teachers indicated being able to get inside a locked classroom in a more efficient and timely manner, noting feelings of safety were more prevalent with automatic locks.
• "Heard shots closed the door and it auto locked and got in corner." • "I felt more safe [sic] in the school when there's automatic locks in compared to the manual locks." • "Students have repeatedly stated that they prefer the auto locks. If a shooting starts and they are near a classroom that does not have a teacher/staff member, they are still able to shut to door and be safe."
Locked Out: While safer and more efficient, participants also noted that automatic doors could result in a teacher or student being locked out of a classroom.
• "When gun shots went off one of my students closed the door, which locked automatically." • "During that time, one of my students closed the door on me because he thought I should've closed the door immediately without looking outside for others. I got back in and we hid safely in the corner." • "I immediately retreated to my homeroom, but it was locked and I had no time to open the door."

Table J-12. Manual Locks Major Theme: Danger.

Manual Locks Major Theme: Danger
Attempts Unsuccessful: Teachers reported numerous attempts in which they were unable to lock doors, either due to heightened stress responses or threat proximity.
• "I was shot while trying to lock my door." • "Since I was unable to lock the door, I tried to usher the students quickly out the front door." • "If the door wasn't a manual lock, but instead automatic, then I think I would've made it out alive, because all I would've had to do was close my door."
Time Constraints: In contrast to automatic doors, manual doors were more time intensive which either placed teachers in danger or led to frustration.
• "The shooter was shooting everyone, so I tried locking the door but it was taking too long…I was killed." • "I tried locking my door, but because it takes forever to lock doors when its manual locks, I couldn't get the door closed." • "Saw shooter coming down purple hall with gun drawn. Couldn't lock door fast enough."
Frustration: Teachers consistently indicated frustration about having to lock doors, getting locked out or being shot while locking a door, and general frustration about manual locks. This was likely due to the time it took for teachers to initiate locks and higher levels of risk involved in locking doors.
• "The manual locks are super annoying and frustrating." • "The runs with no SRO and manual locks, are the WORSE runs." • "Having to manually lock the doors is EXTREMELY [sic] frustrating and stressful."

J.1.2.3 Lockdown Notification Policy

During centralized communications, participants consistently referenced listening for information from the front office and indicated considerable reliance on centralized communications. This emphasis also led to a notable lack of trust when information was inaccurate. Conversely, despite frequent delays or incomplete messaging, teachers felt decentralized communications were more reliable. Teachers used PA announcements to make decisions about evacuating the school or staying inside a classroom. While the responsibility of making announcements brought forth the questions of what should come first—getting inside the classroom or making an announcement—decentralized communications indicated an increased level of responsibility for protocols and student safety.

Table J-13. Centralized Major Theme: Dependence.

Centralized Major Theme: Dependence
Reduce Stress
• "Admin didn't make any announcements even though I radio'ed them twice… caused more panic." • "I saw the shooter shooting at people and got a description and tried calling intl [sic] admin, but I got no response from admin. I was scared the shooter was going to come in the cafeteria."
Clarity Promotes Safety
• "I was able to radio admin the details and description of the shooter in which she relayed to the whole school." • "Once the location was confirmed…we decided to make a break out of the building." • "We realized the shooter was on the second floor we all took a run for it outside and stayed there."
Inaccuracy Impacts Safety
• "Admin had just said the shooter was [in room] 208, but he was in front of me in the teal hall and was down in the blue hall within seconds." • "I heard admin make an announcement that there was an active shooter. There was no location or description information provided." • "The admin then came on again asking if anyone had a location or description. I peeked my head out of my room and saw students and teachers in the glass break room start to panic."

Table J-14. Decentralized Major Theme: Protocol.

Decentralized Major Theme: Protocol
Time Management: Teachers indicated that having enough time to make an announcement and when to make the announcement (e.g., before or after locking a door) was difficult. Many indicated locking doors or student safety took precedence.
• "I attempted to make an announcement to the admin that shooter was in room 108 but I was killed." • "I died early in the run, I failed to notify the admin or the whole school about the shooter as I exclaimed first as initial reaction to seeing a gun." • "I decided to lock the doors before calling the admin, but the shooter got to me first before I could lock the doors. I was one of the first one to die."
Reliable Communication: Teachers indicated that decentralized communications promoted higher levels of situational awareness and were more reliable, despite being less organized than centralized communications.
• "I interrupted Teacher [pseudonym removed]'s public announcement and notified the school that there was an active shooter. The admin relayed the description of the shooter to the whole school, which I am thankful for." • "Gunshots were heard and my student ran in my classroom, I got in and she told me she saw the shooter and where it happened. So, I made the PA announcement." • "I heard gunshots and quickly after heard an announcement that the shooter was downstairs and we should lock down."

J.1.2.4 Shooter Mission

Mass casualty runs elicited more fear and stress, particularly when reports from the admin, shooter proximity, and/or location of the SRO were unknown. Requests for accurate and timely information were more frequent during mass casualty runs, but also more challenging to obtain. In targeted runs, reports of stress or fear were less frequent and situational awareness was higher. The focus shifted from seeking information to a limited number of environmental components that promoted safety, such as communicating with the admin, auditory cues (e.g., shots fired, announcements), and following protocol.

Table J-15. Mass Casualty Major Theme: Situational Awareness.

Mass Casualty Major Theme: Situational Awareness
Threat Proximity: Participants indicated stress/fear when they were in the proximity of the shooter or when they perceived danger.
• "He shot a lot of people, even the people in the break room next door to mine." • "There were a few students who stood at the front of the room right in front of the door window. They got shot." • "I saw a student start shooting teachers and students. I ran down the stairs to my homeroom while announcing on the PA that there was a shooter."
Lower Situational Awareness: When compared to survey responses for targeted runs, participants reported higher levels of confusion and ambiguity regarding shooter location.
• "There was a bit of confusion as to the location of the shooter." • "I stayed hidden in the bathroom when he left until I heard a long silence without any gunshots." • "The shooter was right in our hallway, but left. After a period of silence the teacher decided to open the door to see if he was there. I decided to stand by the door when she left to close it quickly if she was shot."
Communication Challenges: Communication was difficult in mass casualty runs.
• "I attempted to make an announcement to the admin that shooter was in room 108 but I was killed." • "I also called into the admin office so they can make an announcement but it never came. All we had to go on was the shots that were heard throughout the building." • "So, I was trying to get them out then shots were fired, but we didn't know where they were coming from."
Increased Visual Stimuli: Participants more consistently reported visual stimuli, such as dead bodies, during mass casualty runs.
• "I peeked out and there were so many bodies." • "I opened my door to check if the shooter was near and found the hallway and stairs full of bodies." • "I was in the cafeteria and I was going to leave, but the shooting took place super fast [sic]. I hid in the cafeteria and saw a student try coming in but was shot from behind. All down the blue hallway were bodies."

Table J-16. Targeted Major Theme: Environmental Safety.

Targeted Major Theme: Environmental Safety
Protocol Adherence: Targeted runs were more prescriptive and addressed protocol, rather than threat proximity or visual stimuli. Stress responses, in contrast to mass casualty runs, included information regarding following protocol. This may have been due to teachers having more time during targeted runs.
• "I went to my classroom instead of outside to make sure I didn't have any students who needed somewhere to be." • "As I looked outside to gather any fleeing students, I saw dead bodies right outside of the classroom next to mine. I Frantically locked my door with my student inside and called to admin to say there were dead bodies in my hallway but I didn't know where the shooter currently was." • "I was standing by my door as usual, when I saw the teacher in the doorway of [room] 200 fall and I heard gunshots. I closed my door and locked it as soon as I saw that."
Student Safety: Potentially due to teachers having more time to implement protocols during targeted runs, teachers more frequently reported taking actions to ensure student safety.
• "I left my door open for a bit, even though it was risky since the people in [room] 200 were shot. But there were some students stuck in the bathroom and utility closets, so it would be safer for them to be in a locked room." • "I started to lock my door and then I saw a student roaming around. I told him to get in my classroom. I locked us both in."

J.2 Other Observations

J.2.1 SRO versus Shooter: Situational Awareness and Cognitive Loading

Participants' behaviors during the experiment indicated that in contrast with the SRO's situational awareness, the shooter's situational awareness was high and timely, which was fundamental to the shooter's comparative success. Further, the SRO's cognitive burden was much higher than that of the shooter. Both the shooter and the SRO operated within an observe/process/decide/act cycle. Observation enabled the shooter and SRO to process the situation, leading to a decision about what to do next. Incomplete situational awareness could lead to delayed or incorrect decisions. Table J-17 provides four different considerations to elucidate this observation.

Table J-17. Shooter and SRO's Cognitive Loading.

Areas of Cognitive Loading	Shooter	SRO
Clear mission or target	Entered school with firm grasp of target(s) and plan to prosecute (low cognitive load).	The SRO could not know who/where the targets were (high cognitive load for SA).
Complexity of mission	The shooter's mission is comparatively simple—kill target(s), escape (low cognitive load).	The SRO's mission is comparatively complex and multi-faceted—find, confirm, and neutralize shooter, ensure safety of students and teachers, preserve life.
Adequate situational awareness	Shooter starts with high SA—knows target, teachers, students, and SRO by location, voice, and habit (low cognitive load).	SRO doesn't know shooter/must question to discover an anonymous student to be the shooter (high cognitive load)
Timely situational awareness	Shooter has situational awareness about the target's expected location. Only unknown is current location of SRO if present (timely situational awareness).	SRO has late situational awareness at best with current systems. Causes SRO to be continually one or more steps behind shooter (late situational awareness).

J.2.2 Participant Learning Over Time

Over the course of several runs, students in a homeroom or in nearby homerooms came to recognize one another by visual appearance, voice, and other attributes. They developed rituals such as special handshakes, played games such as rock-paper-scissors, and even fostered unique identities through behaviors such as always hanging out in a particular break room. The shooter could be recognized as not fitting into this evolving culture. To help mitigate this effect, students' homerooms were re-randomized and reassigned midway through the experiment.

Some participants noted other ways they learned to recognize the shooter. These included voice and visual appearance (the shooter had a limited selection of visual outfits). Several participants articulated that though they generally recognized the shooter prior to the commencement of the shooting event, they tried to continue in their roles as they would in a normal school situation until it was appropriate to react to a shooter in their midst.

To mitigate this effect, the shooter avatar was given more outfit options and tried disguising his voice, remaining silent, using different pseudonyms, and learning and engaging in student rituals when it did not interfere with the shooter's mission. The shooter would also pretend to execute student missions (e.g., stopping by a different classroom to talk to a teacher before school) in the targeted classroom while obtaining information useful in executing the shooter's mission (e.g., how many students are in the classroom, if the teacher is in the room).

The shooter operator realized that the other participants could recognize him, so he evolved his behavior and tried many different deception strategies over the course of the experiment, including:

- Acting like a normal student in class then suddenly attacking
- Shooting, then concealing the weapon and acting like a normal student
- Hiding under stairwells
- Attempting to mislead others about the location and identity of the shooter
- Pretending to be a normal student in order to get a teacher to open a locked classroom
- Making threats and taking hostages

APPENDIX K: LIST OF ACRONYMS

Table K-1. List of Acronyms.

Acronym	Definition
AI	Artificial Intelligence
ANOVA	Analysis of Variance
CDA	Confirmatory Data Analysis
CISA	Cybersecurity and Infrastructure Security Agency
CONOPS	Concepts of Operation
DHS	Department of Homeland Security
DOJ	Department of Justice
ED	Department of Education
EDA	Exploratory Data Analysis
ENDEX	Run End
FFRDC	Federally Funded Research and Development Center
GMU	George Mason University
HSSEDI	Homeland Security Systems Engineering & Development Institute
IPC	Initial Planning Conference
NASA-TLX	NASA Task Load Index
NPC	Non-player Character
NSEL	National Security Experimentation
PA	Public Address
SA	Situational Awareness
SART	Situational Awareness Rating Technique
SEAL	Simulation, Experimentation, and Analytics Lab
SIMEX	Simulation Experiment
SRO	School Resource Officer
STARTEX	Run Start
SUDS	Subjective Units of Discomfort Scale
TTP	Tactics, Techniques, and Procedures
UAS	Unmanned Aircraft System
VR	Virtual Reality

APPENDIX L: GLOSSARY

Table L-1. Glossary List

Glossary Term	Definition
Lockdown notification	Communication by which the lockdown is announced to the school via the public address (PA) system by the front office (even if a previous announcement was made by a teacher).
Lockdown procedure	The steps the staff, school resource officer (SRO), teachers, and students take once they know a lockdown is in effect.
Notification of a shooter	Communication by which the first teacher (or SRO) notifies the front office by radio or broadcasts via the PA system that there is a shooter.
Record run	A simulation experiment (SIMEX) execution run during which critical data is collected for evaluating the experimental factors.
Wildcard run	A SIMEX execution run during which no critical experimental data is collected, for the purpose of pacing, engagement, and exploring concepts outside the scope of the experimental design.
Training run	A SIMEX run during which data is collected for the purpose of verifying usability and technical integrity, not included in the final data analysis.