Virtual Emergency Preparedness Gaming: A Follow-up Study

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ABSTRACT

Planning processes, including simulations and games, can help emergency workers to prepare for the unexpected. Rehearsal using software based gaming techniques not only helps planning, but is also cost effective. Computer-based groupware systems can make experts available regardless of location. A new approach, Virtual Simulation (VS), uses networking to create a flexible learning and planning environment. To date two prototype trials of this approach have been implemented at NJIT with major revamps between each one. This paper gives the results of the latest prototype trial, a simulation of attacks on university computer centers. The insights from this second prototype trial of virtual simulation will help us to improve the design and approach for future offerings.

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Keywords

Emergency Management, Training, Virtual Simulation

INTRODUCTION

Preparing emergency workers for the unknown is a daunting task. Much planning must be done to utilize real resources and not undermine daily emergency requirements. It is a requirement in these cost conscious times to develop flexible and cost effective new planning methods to offset the deficiencies of traditional simulations that use physical role-playing rehearsals. How effectively can asynchronous tools be used in the planning and training of emergency workers who may not be available for face to face training due to work schedules, cost constraints, or prohibitive distances?

In addition to high cost, traditional simulations require rigid scenario design. They may lack the ability to utilize key personnel over an entire game due to conflicting work priorities. The timeframe for the physical simulation cannot often be the same as a real event as volunteers are willing to give only a few hours per day at best. One needs to consider that real crisis events can extend over days, weeks, or even months (Yao 2005). The ability to simulate such events over their true time period will provide increased realism.

Information technology provides an excellent platform to enhance our emergency management training. Group communication software (such as WebBoard from Akiva Corporation or WebCT from WebCT, Inc.) provides the participants in the process planning game with both synchronous and asynchronous communication capabilities. Topic threads organize the discussions among and between the participants for later review and analysis. The Internet provides the connectivity among dispersed participants so that physical attendance and synchronous participation is not required. Using the combination of Groupware and the Internet, our team at the New Jersey Institute of Technology proposes a new training

approach called Virtual Simulation (VS) (Turoff 2005). Virtual Simulation's greatest advantage over traditional planning processes is that there is no pre-established model or hard-coded rules to follow.

There is currently no empirically confirmed approach for using Virtual Simulation. The authors provide preliminary results based upon various research domains including planning, cognitive psychology, social psychology, and gaming. The approach has four main components: 1) scenario composing, 2) mental rehearsal,3) critical thinking, and 4) information seeking. These components guided our most recent prototype trial of Virtual Simulation.

CHALLENGES OF TRADITIONAL EMERGENCY MANAGEMENT SIMULATION TRAINING

Simulation is one of the most widely used and effective approaches to train emergency management personnel. It can create similar types of tension and emotions as real emergencies. Klieboer believes that simulation is a useful way to practice skills and expose potential problems in real situations(Kleiboer 1997). Others have challenged this opinion. Borodzicz made a distinction between physical and psychological fidelity (Borodzicz 2002). It is very difficult to reproduce disaster scenes. Physical realism will not necessarily generate psychological realism. Simulation with high fidelity, that is high realism, is very expensive and time consuming to prepare. It is common for such simulations to be practiced only once per year. Both Borodzicz and Robert have warned that improper simulation design would compromise training effects (Borodzicz 2002) (Robert 2002). Planned, rigid scenario designs have much difficulty keeping up with creative attacks and threats such as the 9/11 attacks.

NEW APPROACH: VIRTUAL EMERGENCY PLANNING SIMULATION

Turoff, et. al., address the problems and challenges of traditional emergency management training by pursuing a new approach, a virtual emergency planning process using group collaboration software (Turoff 2005). The training approach is called "virtual" because 1) participation in the simulation occurs in a virtual space. There is no physical participation necessary. 2) No scenario is pre-determined. The attack scenarios are written as a by-product of the virtual simulation. 3) No modality is pre-defined; any possible input is acceptable in the simulation The goal of this research is to change emergency management training so that it can be 1) flexible, 2) easily delivered, 3) steer critical thinking, and 4) foster creativity, as follows:

1. Flexible. Virtual simulations can accommodate almost any emergency disaster type. No specific scenario or model is needed to begin the simulation.

2. Easily delivered. The only required equipment to run the simulation is a PC, an Internet connection, and an appropriate groupware package. The participants do not need to be onsite or attend the simulation at the same time as others. There is no limitation as to where participants are located, so long as they have a PC and Internet access. There is no limit on how often or when a participant is in the simulation.

3. Steer critical thinking. The planning process simulation allows for collaboration in real-time over an extended period. This extended period can allow for deeper cognition of options and a possible better result.

4. Foster Creativity. The group participation over an extended period allows for discussion and synthesis of new ideas. Whether these are better ideas is a research question.

Our main research question is: Can a continuous ongoing game involving decision makers, responders, and emergency management professionals across many organizations and agencies act as a mechanism to 1) Expose comflicts in command structures, 2) promote cooperation in realistic unexpected situations, create effective virtual teams, 3) Create trust between organizations, 4) train professionals to handle multiple roles, and 5) foster respect necessary for collaborative teams to exchange roles when needed? (Turoff 2006). Our premise is that Virtual Simulation can provide added value to the trainees through its online collaborative learning environment.

Methodology

"Scenario Composing" has been presented as a useful planning tool for the proposed Virtual Simulation approach (Turoff 2005). However, "Mental Rehearsal" and "Critical Thinking" are also important concepts for simulation games. We will discuss each of the three methods and then provide a synthesized model for conducting the online emergency preparedness simulation.

Scenario Composing:

A scenario is a set of activities or events related together by "what if" situations (Fahey 2000). There is a wide range of scenario applications, especially in the planning area. Information analysts study the scenarios to gather the requirements for use cases. Managers and other knowledge workers use scenarios to prepare forecasted values(Duncan 1994). Fahey found that scenario learning is a useful way to anticipate future trends especially in fast changing markets (Fahey 2000). Scenarios are a good way to solve complex, unstructured problems in a structured environment (Kavakli 1996).

Mental Rehearsal

Athletes use mental rehearsal as one part of their training. Game situations are replayed over and over in the athlete's mind to ready themselves for actual play. Mental rehearsal is the main approach for mental practice, a method used to improve performance. Driskell defines mental practice as "the cognitive rehearsal of a task in the absence of overt physical movement" (Driskell 1994). For the emergency management domain, mental walkthroughs can be used to judge the feasibly of attack and defense plans and to find the pitfalls in each. .

Critical Thinking:

Critical thinking is based on a questioning attitude. People who use this method use their own judgment in determining what to believe and what not to believe. During emergencies, workers are surrounded with a huge amount of information, and need to determine whether it is correct or not. Critical thinking is used to discern good information needed to handle the emergency and to filter out superfluous information known as "noise" (Douglas 2000), (Turoff 2004).

Synthesized Model, Including Information Seeking:

A preliminary approach for on-line emergency preparedness simulation training is illustrated in Figure 1. Information Seeking is added as an important component of decision-making, which can be supported well in asynchronous planning processes. Emergency Planning is not only mental work, but also a component of actual endeavors (Weick 1987). Solid lines represent the flow of thoughts or information. Dotted lines represent the effect of supporting or perturbing one component on another.

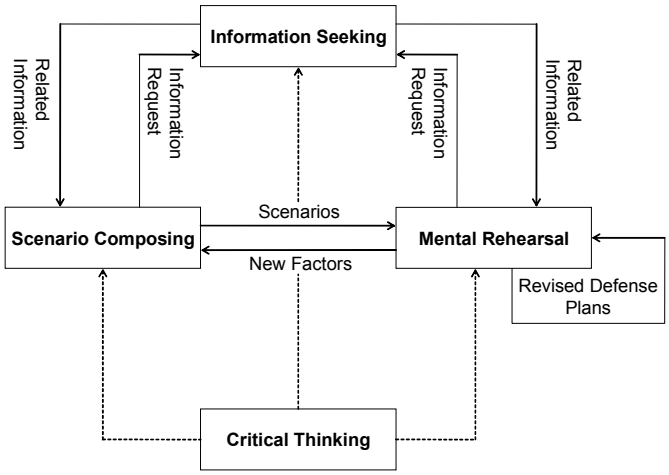

Figure 1: Approach for emergency preparedness simulation

CASE STUDY

The first emergency preparedness simulation-training program in NJIT was conducted from October to December, 2004. There were 23 undergraduate students initially participated in the experiment, and 19 in the end. Results were reported in

(Yao 2005) The second emergency preparedness simulation training prototype trial at NIJT was conducted from March 16, through April 30, 2005. There were 28 graduate students initially participating in the simulation and 23 students completed. This section describes the second virtual simulation prototype trial, and summarizes and discusses our observations, with some comparisons to the first trial. .

Procedures

Participants

The participants were divided into three groups: offense team, defense team, and intelligence team, comprised as shown in Table 1:

	Offense Team	Defense Team	Intelligence Team
Beginning	10	12	6
End	6	11	6

Table 1: Constitution of the Teams

In addition to the 28team members, roles included an Overall Game Director (OGD), monitoring the progress of the simulation gaming, a Judge to oversee the use of resources, a offense team spy to leak information to the intelligence group, and a defense team spy to leak information to the offense team.

Tasks & Roles:

The targets for the simulation's offense team were the computing facilities at the New Jersey Institute of Technology and Rutgers Newark, New Jersey campuses. It was left to the participants to determine what type of offense to protect against or perpetrate. The offense team was asked to create scenarios that would disrupt computing at the universities. The defense team was asked to design plans that would guard against the offenses. The Intelligence Team received an offense report submitted by a "spy" planted as a regular team member. The Offense Team received covert information from a spy planted in the defense team. The Overall Game Director (OGD) communicated the reports between the teams after review by the Judge. The Judge ensured that the spy reports did not compromise the spy's identity.

Processes:

The first week was used to administer the userid assignments and for socialization in the anonymous, pseudonym environment. For the remaining weeks, there were rounds of planning, spy leaks, resource requirements, and approval for continuance. Reports from the spies and the offense, defense, and intelligence teams were submitted on Friday nights. The reports were approved by Sunday night and the "leaks" posted to start the next round. The defense team also posted a public safety plan for all teams to read.

Platform:

WebBoard was the only information exchange medium. WebBoard was chosen because it is an asynchronous, web-based, threaded discussion system which allowed assigned pen names so that players could remain anonymous.

At the start of the game, the OGD created different private conferences for the Defense Team, the Offense Team, and the Intelligence Team. Nobody in one group was able view another group's discussion, except for the "public defense plan".

Observation & Analysis

A. Observations about team activity

The Intelligence team was more active than the Defense Team, which in turn was more active than the Offense Team.

The finding that the Intelligence team is more active than the Defense Team and more active than the Offense Team is different from the first prototype trial of this approach. In Trial 1, the Offense Team was the dominant group. Intelligence Team members from the beginning of this second prototype trial showed a higher degree of involvement.

In the first prototype trial, the dominant group volunteered easily for specific duties. In this prototype trial, the election of the group leader was met with resistance. In one case the participant who refused election as leader, became the dominant participant. The Intelligence Team gelled quickly from the time of their socialization period. They were more reactive to their peers' postings and more likely to support one another as deadlines neared. They also had a responsive team leader. The timing of the game's beginning, the week before spring break, seemed to delay the active participation of some members.

Analysis: The different involvement levels occur for a variety of reasons. Leadership is one. Task characteristics may be another factor to consider. Daft and Lengel's two-force framework (uncertainty vs ambiguity) helps to analyze an organization's information processing (Daft 1986). The three-team roles can be studied in this light. In the emergency preparedness simulation, the uncertainty stems from the unpredictability of the offense. Will the offense be physical against a computer room or virtual against the email server? Will biological offenses be implemented to make students and computer operators ill? What role do the spies play in keeping us safe or adding to the offense level? The three teams can be placed in the Daft and Lengel framework as shown in Figure 2, which shows the relative task complexity of the three groups as:

Defense Team > Offense Team > Intelligence Team.

This model helps to explain the levels of activity between the teams.

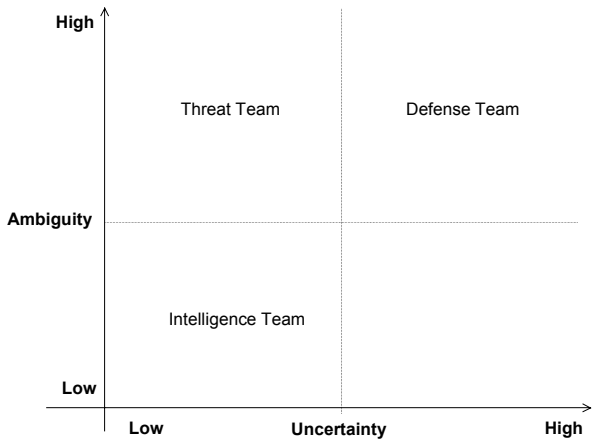

Figure 2: Two-Force Framework on Information

Requirements in Emergency Simulation

The Defense Team had the most complex task, by far. They did not know the type of offense for which they had to prepare, nor was it known how to handle each type of offense. With the exception of the team leader and one other member,

most of the group was mute. The mute members seemed perfectly content to let the two main participants shoulder the load as they adopted an avoidance of work strategy. This may have been influenced by timidity, a lack of work ethic, or scheduling conflicts.

The Intelligence Team had the least complex task, as its responsibility was limited to filtering information from the offense spy to the defense team and interpreting the information given to them by the defense team's public plan and private plan. This availability of spy information and defense information lowers the ambiguity faced by the team. Despite this lower ambiguity, this team was the most motivated, spurred on by an active leader and an able assistant. The intelligence team also gathered public information from the Web and should have had more guidance to try to reduce uncertainty for the defense team.

The Offense Team had a different scope of work from the other two teams, as the work that was required was neither too complex nor too ambiguous. Despite the theoretical upside of "not too complex/not too ambiguous", the team let the leader do the bulk of the assignment. This did not help the morale of the overall team. One complaint voiced by the members in the post-game de-briefing was that some members wanted to do a physical attack; others wanted to do a virtual attack. This team never gelled.

B. Observations about the platform

Use of pre-defined discussion threads was not favorable.

Prior to the beginning of the game, the OGD created several root items in the WebBoard. As in the first prototype trial of this game, the teams thought that this arrangement was too rigid and basically ignored the predefined root items. There was some discussion as to when they should use the predefined root items, what the root items actually meant, and when they should use their own. In order to limit this side discussion on when to use what conference, the leaders of the groups just went ahead and created their own root items. Table 2 shows how the teams used the root items compared with the Trial 1.

	No. of pre-defined root items	**No. of used pre-defined root items**	**No. of newly created root items**
Offense Team	12 vs 12	9 vs 6 (with 3 used by OGD/Judge)	5 vs. 8
Defense Team	15 vs. 17	11 vs. 11 (with 2 used by OGD)	5 vs. 17
Intelligence Team	3 vs. 12	3 vs. 9	10 vs. 10

Table 2: Discussion root items distribution, Prototype Trial 2 versus Prototype Trial 1.

The use of the conferences for this prototype trial versus the first is in line with Adaptive Structuration Theory (AST), where online discussion groups find their best organization for maximum communication. DeSanctis predicts that groups will self organize versus following a pre-defined design (Desanctis 1991). This result was similar to that of the first prototype trial and gives us a hint that the groups should self-organize in the future.

Problems with tools

Prototype Trial 1 found problems with the assumption that students had prior WebBoard experience. Prototype Trial 2's feedback confirmed this as a problem. A WebBoard tutorial before the game would be helpful.

As in the first prototype trial, there was a clamor for the use of other tools in conjunction with WebBoard. One student in particular relied on the email notification function to motivate his/her responses. With email notification disabled, this student found the continual logging in to check comments to be a waste of time. The upside to disabled email was that we successfully prevented communication between members that would otherwise not have been recorded for analysis. The downside was that one useful feature of WebBoard was disabled. Some students asked to use a chat client. Although WebBoard has this capability, we asked students to only communicate through WebBoard postings. Other chat clients, such as MSN, could be used in the future to ensure that discussions are recorded for analysis.

C. Observations about participant perceptions (

Reactions to the game itself

The three teams found that the unstructured nature of the game was a good way to learn emergency preparedness. One notable exception was a participant who wished to see more structure. Unfortunately, emergency workers do not have the luxury of preplanning and structuring the way real scenarios will be played out. In the case of 9/11, Ken Holden, the Commissioner of New York City's Department of Design and Construction (DDC) described his first impression of the chaos of that day as, "[The scene at Ground Zero] was hallucinogenic-quasi-druggy, with flares shooting up and death in the air. There was a sense of crazed panic, people fighting to save their lives, fire hoses cascading all over the place (Langewiesche 2002)." Events such as terrorist attacks do not lend itself themselves to structure.

Participants on the Defense Team were confused as to what to protect. This mirrored the confusion on the Offense Team where they were confused as to how best to attack. Many postings were made asking the leader for clarification. There were also pleas for the OGD to be more involved in structuring the tasks.

Elections for the team leader position were a fair way to consider the participants' outside schedules. Self-election may be more realistic for future prototype trials. Self-election occurs at emergency scenes, when no obvious leadership is visible, or the leader has become incapacitated (Langewiesche 2002).

The Offense Team continually discussed whether a logical or physical attack would be most effective. Based on information leaks from the implanted spy, the Defense Team divided itself into two groups to cover both possibilities.

Information Overload

As in the first prototype trial, the students in this experiment felt overwhelmed by the amount of information given during the start-up. While the directions of the game were changed from the previous prototype trial, a "management summary" with bullet points would be a helpful addition for reference during the game. The OGD was also concerned with his role. It was unclear how much the OGD should inject himself into the play, either for clarification of issues or for evaluating any proposed scenario. The OGD limited himself to clarification of the rules and forwarded the comments from the spies to the target teams. The workload was also a complaint. Our initial estimate of about 3 hours per week for each participant was not realistic. Some participants spent less than one hour per week. In another case, the leader of a team did most of the research, write-up, postings, and follow-up. The time expended by this leader was more than 6 hours per week.

These observations and suggestions must be put into the perspective that the ability to deal with information overload is an important skill for emergency workers. Proper collaboration can leverage each team member's skills and cover for other outside activities.

D. Other Observations (

Creativity

One goal of the game was to observe the creativity of the participants to handle unknown situations. This goal was achieved throughout the game with new proposals and counter proposals developed throughout the prototype trial. The use of a spy to leak information to the offense and defense teams allowed the teams to narrow their responses to those proposed by the other side.

An unintentional leak by the OGD via the game directions gave rise to the use of disinformation to conceal real plans. The use of disinformation by the Offense Team kept the defense on edge. This leak was not planned but resulted in lively debate among the participants. We expect as more prototype trials of this game are performed, the creativity will increase and help improve the game even more.

Focus

In this prototype trial we narrowed the focus of the offenses from a broad range of targets in New York City to the campus computing facilities at NJIT and Rutgers-Newark. We did not restrict the timing of the offense nor the type of offense. As the Offense Team changed from physical to logical attack scenarios, the Defense and Intelligence Teams needed to respond. This shifting between the two types of attacks added to the workload of the intelligence and defense teams. In response to the logical attacks, the discussion was peppered with much technical jargon, leading one member to comment, "there were times when things were simply too technical (virus and security jargon)." The beginnings of deep technical discussions showed the seriousness to which these team members thought about their tasks and should not be discouraged.

The teams helped narrow the focus of the offense to only the NJIT campus as information was sketchy about the Rutgers computing facility. This type of self focusing also occurs in real emergencies. A better starting point may have been "logical attacks on NJIT". Less energy will be expended on searching for information outside the purview of the game. More time can be expended on deeper research.

Feedback

As in the first prototype trial, participants generally thought that the level of feedback from the "authority figures" (OGD and Judge) needed to improve. Some students thought that the OGD was involved too much and others thought too little. The OGD himself admitted to being confused as to the proper level of involvement.

To make the game more interesting, a clear timeline of events needs to be developed. This timeline was not effectively communicated to the teams.

In both prototype trials of the game, we provided only operational feedback. Except for the judge presiding over the use of resources there was no feedback given on how well a plan could be implemented. This is a shortcoming that needs correction in future prototype trials. Once evaluative judgments are made, a scoreboard could be provided for teams to see how they are comparatively performing.

Results

Participants filled out a follow-up questionnaire with 66 items after each prototype trial. The questions used a scale ranging from 1 (strongly disagree) to 7 (strongly agree). Overall scores from the first prototype trial and second prototype trials did not significantly differ on an overall team basis. There was some disagreement by individual question. Differences for key questions follow in Table 3:

	I agreed with the team's final report	**Leader had to assign work to proceed**	**Team produced useful ideas I couldn't do alone**
Offense Team	4.6 vs 5.7	4.6 vs 2.9	5.6 vs 4.7
Defense Team	4.3 vs 6.0	4.5 vs. 2.7	5.6 vs. 4.8
Intelligence Team	5.0 vs. 6.8	5.0 vs. 3.5	4.3 vs 3.7

Table 3: Questionnaire results differences, Prototype trial 2 versus Prototype trial 1.

In the first prototype trial the results indicate that a higher degree of team spirit existed. In the second prototype trial, the teams relied more on assignment from their leader than on individual motivation. Although the individual team members did not agree with the final report, they all thought that the Virtual Simulation approach led to ideas that they would not have thought of themselves.

IMPLICATIONS

This second prototype trial of the virtual simulation emergency preparedness game provided additional feedback for improvement. First, the tasks need to be more focused. The tasks should not be too restrictive, but neither should they be too broad and flexible. In an academic situation, we must realize that the semester will come to an end whether we like it or not. Other demands on the students' time will impinge on their ability to learn. Second, the groups should be selected based on their prior experience. One group had someone who had participated in disaster recovery operations at a bank. Opposed to this level were those who were confused by computer jargon. A pre-screening survey should be administered to balance the teams in terms of experience. The less experienced can learn from the more experienced to raise their basic knowledge. Third, a training session on WebBoard and the game in general will focus the participants on the task and not the technology of participation.

FUTURE WORK

We will continue improving the Virtual Simulation method. Our emphasis will be to incorporate the feedback from our early participants and rework the design of the game. For students new to the area of emergency preparedness, the cycle time has been quite long. They exhibit a lack of knowledge of how to prepare a scenario and execute an emergency plan. Our future trials will include a database of template scenarios and the events that comprise them. The teams can then use this base as a springboard for more sophicated planning instead of spending inordinate amounts of time only learning the technology. We also plan on the use of professional emergency workers as a validation method of the approach. Our ultimate goal is to make Virtual Simulation a practical and most useful training approach for all levels of emergency workers.

CONCLUSION

Today's emergency workers are faced with the daunting task of finding effective, yet cost effective alternatives to prior methods. Virtual Simulation has the potential to provide scenario planning that is a cost effective supplement to traditional, physical simulations. This new form of planning simulation provides flexibility and ease of preparation while stimulating creative and critical thinking. This new type of simulation is undergoing the expected growing pains before it generates the anticipated benefits. This article follows up on the initial prototype trial. With more prototype trials we will bring Virtual Simulation closer to enhancing the four most important areas of emergency management preparation: information seeking, scenario composing, mental rehearsal, and critical thinking. This case study of the second prototype trial at New Jersey Institute of Technology in Spring, 2005 shows that issues such as complexity, platform, information overload, and coordination, that were found in the first prototype trial still exist. We are still far from perfecting Virtual Simulation as an effective training approach. We will continue our field studies to discover ways to improve the learning experience.

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