# Developing a serious game to evaluate and train group decision making skills

Conor Linehan, Shaun Lawson, Mark Doughty, Ben Kirman

Lincoln Social Computing (LiSC) Research Centre,

University of Lincoln. Brayford Pool, Lincoln, UK LN67TS

+44 (0) 1522 837084, {clinehan, slawson, mdoughty, bkirman}@lincoln.ac.uk

## ABSTRACT

The current paper describes the building of a serious game designed to teach group decision making skills to a unique audience; people who co-ordinate responses to real-world emergencies such as floods, fires, volcanoes and chemical spills. Eighteen participants were recruited and videotaped while playing a paper prototype of the game. Players' actions within the game were analysed in terms of whether the challenges that are present in real world decision-making environments are also present in the game-world decision making environment. It appears that the defining characteristics of group decision making behaviour, especially the mistakes, are evident in groups that play our game. In addition, the round-based game structure allows a tutor the opportunity to deliver in-depth qualitative feedback without interrupting game play. Thus, the game design should prove to be a valid environment in which to train, practice and evaluate the decision making behaviour of groups and function as a valuable and engaging part of a group decision making skills training course.

## Categories and Subject Descriptors

K.8.0 [Personal Computing]: Games - *General.*

## General Terms

Management, Measurement, Design, Experimentation, Human Factors, Theory

## Keywords

Serious games, serious games methodologies, game & simulation design, education and learning, management, emergency management, collaborative games, paper prototyping.

## 1. INTRODUCTION

If designed correctly, serious games can utilize the inherent motivation demonstrated by game players in order to teach skills that are of immediate practical benefit [6, 24]. The intended transfer of game skills to real world activities is what ultimately differentiates serious games from entertainment games.


*MindTrek 2009*, September 30th-October 2nd 2009, Tampere, FINLAND.


The challenge of designing a successful serious game depends on ensuring that the skill being taught and practiced in the game is functionally identical to that which is required in the real world. In order to ensure that this is the case, the particular real-world challenges faced by the target audience must be evaluated, and efforts must be made to generate a game environment that accurately models the functional characteristics of these challenges.

The current paper presents work being conducted as part of an EU LEONARDO funded project named DREAD-ED, which aims to utilize distributed multiplayer computer game technology in the training of emergency management personnel (see http://www.dread-ed.eu for further information). The project aims specifically to train emergency managers in 'soft skills' such as communication, group-based decision making and decision making under stressful, dynamically changing circumstances with incomplete information (see [15, 16] for further discussion of this project).

The DREAD-ED game will form the experiential learning component of this larger training program that will also feature traditional classroom-based face-to-face training. As such, it is not intended for the game to explicitly teach the concepts of sound group decision making. Rather, the game is designed to represent a realistic environment in which to make group decisions. Essentially, the game provides the context in which to practice all of the relevant skills. Thus, the particular game design adopted must generate a game environment that accurately models the challenges faced by emergency managers when making decisions collaboratively under stressful and dynamically changing circumstances.

The process of designing a game that functions as part of a program for training emergency managers in group decision making skills is presented below. Initially, the state of the art in serious games design is examined, particularly in regards to games that train skills. Subsequently, the unique challenges presented by teaching a target audience of experts are discussed. The social psychological research on decision making groups is briefly summarised, before a description of the DREAD-ED game design is presented. A formative paper-based evaluation of this game design is presented, along with some conclusions and suggestions for further work.

## 2. DESIGNING USEFUL SERIOUS GAMES

It could be argued that all commercial games are educational, as they train players to be increasingly fluent at manipulating the system for gaining success within that game. The challenge of

progression within a game provides motivation to continue learning [18, 24]. Essentially, good games make the process of learning fun [26, 13]. This is precisely the reason why games have recently been seen as an exciting development in education. If designed correctly, serious games can utilize the inherent motivation demonstrated by game players to teach skills that are of immediate practical benefit [6].

## 2.1 Intrinsic Learning

Combining psychological research and games design principles offers a framework for developing educational games that promote learning while maintaining high motivation of the players [19]. Unfortunately, a large number of educational, or serious, games appear to have ignored recommendations on serious game design, particularly in regard to two issues; embedding learning outcomes within the game mechanics, and providing immediate and specific feedback to participants regarding their behaviour.

As mentioned above, a successful serious game is one where the task learned in the game maps directly on to the challenge faced in the real world. This feature has been referred to by Habgood [7] as intrinsic learning and by Bogost [1] as procedural rhetoric. Both authors essentially refer to embedding the learning outcomes of the project within the mechanics of the game. Bogost analyses a number of serious games that are deficient in procedural rhetoric (p. 49-51) and also a number of games that excel in this respect (p. 29). Furthermore, Habgood investigated experimentally the importance of integrating learning content with the mechanics of a game. Specifically, in two studies, the author found that a game in which learning was intrinsic to game play was motivationally and educationally more effective than an almost identical game in which learning was not intrinsic to game play. A successful serious game must locate the learning within the game play mechanics, rather than as an addition to the game play mechanics.

## 2.2 The Importance of Feedback

Engaging computer games excel at providing immediate, appropriate and specific feedback to players. This feature is at the heart of the motivation, sustained attention, learning and fun experienced by game players [19, 17]. It is also a feature of any sound manual or cognitive skills training program and is a reliable predictor of future performance of those skills [3]. Indeed, the power of feedback has been consistently demonstrated as a key variable in the process of learning over the past seventy years by behavioural psychologists working under the paradigm of operant conditioning (see [3, 20, 5 and 21] for in-depth analysis of this topic). Operant behaviour identifies a situation where the, "consequences of behaviour may 'feed back' into the organism," and, "when they do so, they may change the probability that the behaviour which produced them will occur again" ([20] p.59). For example, a rat may engage in many behaviours while trapped in a cage. If one of these behaviours, such as pressing a lever, is followed by a favourable consequence such as the delivery of food, the probability of this behaviour occurring in future will have been altered (in this example it will probably be increased).

Interestingly, Loftus and Loftus [17] conducted an in-depth behavioural analysis of the behaviour of playing computer games. The authors draw comparisons between a person playing Pac-man and a rat in one of B.F. Skinners classic behavioural experimental preparations. Operant conditioning, and specifically the process of reinforcement, is proposed by Loftus and Loftus as an explanation of game player's sustained attention and motivation. It appears that successful entertainment games excel at delivering the correct type of feedback (both positive and negative) at the correct time. Thus, it appears that educational games must learn from the success of entertainment games, as the process of providing clear, immediate and specific feedback is essential in shaping behaviour of game players.

## 2.3 Skills Training

It must be noted that games designed to train skills also face different challenges to those designed to impart information. As it is intended that the skill learned in the game will transfer directly to the real world, participants in a skills training game should be engaged in precisely the same behaviour in the game environment that they would be in the real environment. The game environment should consist of features that correspond to reality, both in terms of the 'choice architecture' (the dynamic system of game mechanics in which decisions must be made) and also in the consequences of behaviour. Successful real world behaviour should have positive game consequences (This point was addressed in further detail in a previous paper [4]).

# 3. TRAINING EXPERTS

Most serious games are aimed at the general public and are designed to generate behaviour change in large amounts of people, typically through delivering information. Alternatively, some serious games teach by presenting players with the opportunity of interacting with a model of the system that is being taught (such as *McVideo Game*[1], *Redistricting Game*[2] and *3rd World Farmer*[3]). However, these games are always aimed at a large number of people and assume a starting point of little or no knowledge about the system. The current project has a very different audience; namely experts. DREAD-ED aims to train people who are already experts in emergency management to do it better. The resulting game design must be radically different to the type of information-driven serious games that are the norm. A number of challenges are presented by the very expertise of these target participants.

The first challenge presented by the task of training people who are already experts is the problem of information. Specifically, because the participants are experts, centering the game play on information, as is the case with a large number of serious games, can lead to both pedagogical challenges and design challenges. If any procedural or informational discrepancy exists between the game environment and that which is the case in reality, it will be noticed by these expert participants. This has the potential to break the participants' engagement with the game environment, and thus the power of the game will be lost.

The second challenge presented is the necessity for learning outcomes to be generalisable to a large number of different possible events. Specifically, because the procedural knowledge required to deal with an emergency is so specific for each different type of event, a game that is based on 100% accurate information for one particular emergency will not be generalisable

[1] http://www.mcvideogame.com/,

[2] http://www.redistrictinggame.org/

[3] http://www.3rdworldfarmer.com/

to the countless other different events that these participants may have to deal with. A game designed to train people who manage forest fire related emergencies in Spain will be of little use to a team that manages flood related emergencies in France, if procedural knowledge and information is the primary focus of game play.

Rather than focus on the information and procedures of management, for which training courses already exist, we have decided to focus on training generalisable group decision making skills using an abstract model of a developing emergency event. In this way everyone who plays the game will gain benefits. This approach will circumvent the problems of generalisability and of the potential for incorrect information to disengage players from the game. In addition, there is currently a lack of pedagogically sound, engaging courses designed to teach group decision making behaviours.

## 4. DECISION MAKING GROUPS

Decision making groups are formed on the expectation that decisions made by the group as a whole should be better informed, more considered and ultimately more successful than decisions made by individuals. However, decades of research has demonstrated that this is rarely the case [11, 23, 10, 9, and 22]. Few studies have reported that groups have performed as well as their best member would have individually, and fewer studies still have reported group performance that is better than the performance of any individual efforts. Thus, it appears that efforts should be made to identify a qualified individual and let that person make decisions rather than forming groups to do so.

While the above seems unequivocally true, real world emergencies will necessarily be managed by groups. It is not possible to set one person to manage an emergency, as one person on their own will never have access to all of the relevant information needed to manage the situation. Even if one person is ultimately responsible for the most important decisions made during an emergency event, this one person must still deal with a group of subordinates who gather and process information in a similar way to that observed in group decision making. Regardless of whether the team is set up with an authoritarian or democratic decision making structure, the core elements of information gathering and processing are omnipresent.

## 5. DESIGN REQUIREMENTS

In order to create a game to train groups in decision making skills, it is necessary to provide a game environment that resembles a real decision making environment as closely as possible. All decision making groups must perform an information search, share this information in a structured manner, must keep track of which member knows what information, must participate equally to ensure that a minority of members do not become dominant and must actively listen to and consider minority in order to avoid the symptoms of groupthink. In making a decision, these groups must combine the knowledge of how the environment works with the resources available in order to make decisions that are most beneficial. In addition, groups tasked with emergency decision making must deal with time pressure and stress, which tends to narrow a groups focus and leads to mistakes (see [11, 23, 10, 9, 22] for a full review of the literature on group decision making; also [16] for a discussion of how these issues impact on the current project). Thus, a game designed to train group decision making should present players with these exact challenges.

In addition, competent players playing on their own should be more successful at the game than in a group. Examining whether that was the case would illustrate whether the game is a useful tool, in that it models accurately the complexity of a valid decision making environment. Untrained teams should also be prone to making errors within the game that are commonly observed with decision making groups. For example, under stressful situations, groups should make inefficient and risky decisions. If the above are found to be the case in the DREAD-ED game, then a course can be constructed that uses the game as a "sandbox" to practice the skills required in real decision making events.

## 6. THE GAME DESIGN

A game design was created based on the requirements identified by the literature review. The game places players in an emergency management team that is dealing with a developing emergency. Each team member is assigned a role that has unique abilities within the game. The information that is needed to solve the problem posed by the game is distributed among all game players in the form of personnel. In order to successfully manage the situation, personnel must be exchanged between group members. All players must effectively communicate their unique information to the other players and appraise the many courses of action available before making decisions.

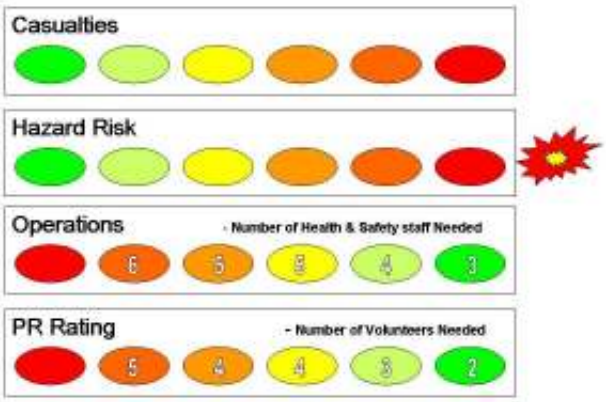


**Figure 1. Paper prototype representation of the game state.**

### 6.1 Goal

The challenge presented by the game lies in managing the dynamically changing game state, which is represented by four six-point scales (see Figure 1). Each scale represents an individual aspect of the emergency that can vary from 1 to 6, representing 'perfect' to 'disaster.' These scales are labeled as 'casualties,' 'hazard risk,' 'operations,' and 'PR.' The 'casualties' scale is the most important of the four scales in terms of evaluating team performance. If the casualty scale reaches its maximum, the team has lost the game. Conversely, if the management team ensures that the 'casualties' parameter does not increase, then they have completed the task successfully. Events, or 'injects' of information that alter the game state in an unpredictable fashion are introduced at specific points in order to model the dynamically changing nature of an emergency. This

feature is designed to force players to plan in advance for unforeseen circumstances, as well as dealing with issues of immediate importance.

## 6.2 Game Mechanic

The game mechanic is based on assembling and deploying teams of similar personnel in order to affect the values displayed on the game state scales. Each of the nine personnel classes has a unique effect upon the game state when deployed. In addition, each player character, or role, has a unique ability, some of which relate to particular personnel classes. A high-achieving group will excel at getting the right personnel to the right players at the right time in order to control the emergency. A mechanic was developed that limits the number of actions available to the group each round. This mechanic, coupled with the limited time available for discussion and collaboration, was designed to create a stressful decision making environment.


**Figure 2. Graphic representation of the player role and personnel team of four players of the DREAD-ED game. Note that arbitrary colours have been used here to represent the different personnel types.**

## 6.3 Presenting Feedback

The game has been carefully designed to present an environment where it is advantageous to engage in the appropriate group decision making and communication behaviors [16]. Groups that do not work collaboratively to solve the problems presented in the game should perform poorly. Thus, the learning outcome is embedded within the game play mechanics and the game state itself should provide feedback on how well the group is performing in terms of soft skills. In addition to the ongoing feedback delivered by the game state, the game has been carefully structured to work in rounds, each separated by a phase in which a tutor has the opportunity to give more detailed feedback to players. The first timed round is assigned four minutes for discussion and action, and each successive round is assigned twenty seconds less for discussion and action than the previous round. Once the full number of timed rounds has elapsed, an in-depth evaluation phase is initiated between the tutor and the participants.

# 7. EVALUATION

In order to evaluate the game design, a paper prototype was created using cards and a game board. The construction of a paper prototype allows for the careful examination of game mechanics without the development costs associated with an electronic version. Cards were used to represent the character roles, personnel classes and event injects, while a game board was used to represent the game state and also to keep track of the number of actions taken by groups in each round of the game.

**Figure 3. Pilot participants playing a paper prototype of the game design.**

Eighteen participants (10 male, 6 female) were recruited from a sample of convenience and paid £10 upon completion of the game play session. It must be noted that these participants were recruited from a sample of convenience and were not emergency management personnel. Participants were divided into four groups of four players each. The game rules were explained by a researcher via written instructions that were read aloud while making reference to the cards and game boards on the table. This was followed by a practice game round, in which all three game mechanics were demonstrated and the functions of different role and personnel cards were explained. No hints or tips were given by researchers in relation to the most effective strategies for playing. This was part of the challenge presented by the game. In addition, when playing, participants were not allowed to show their cards to other players, rather they had to communicate this information verbally. Once participants had indicated that they fully understood the game rules, the first game round was initiated. Participants were video recorded while they played, and these recordings were later analysed in order to evaluate group effectiveness.

Efforts were made to ensure that all four groups faced exactly the same challenge and were supplied with exactly the same resources. In order to achieve this, the game parameters were set to common values at the beginning of the game across all four groups. In addition, the decks from which personnel cards and event cards were drawn were arranged so that they were the same across all four groups. In this way, the resources and challenges presented both at the beginning of the game, and also as the game progressed, were the same across all groups. Thus, better performance of one group over another group could only be attributable to a better use of the resources available.

While the game is designed to be played in the presence of a tutor in the final DREAD-ED training program, the current study did not employ a tutor in this role. The presence of a tutor in the current study would necessarily shape players' behaviour towards that which has been defined as appropriate. The current study is interested in evaluating the game environment itself, rather than the success of a tutor in utilising that environment, so the presence of a tutor was not necessary.

## 7.1 Previous Findings

A previous study [16] indicated that when two groups were evaluated, the group who performed better in terms of game success also exhibited more equal participation of group members and more total time spent talking than the lower achieving group. These findings suggest that the game delivers appropriate feedback to players on their collaborative behaviour. The current evaluation focused on determining whether the game provides an engaging environment that reflects a real emergency in which participants can practice the skills of group decision making. A number of research questions were developed, based on the group decision making literature, in order to verify whether this was the case.

## 7.2 Research Question 1

The first question investigated whether the DREAD-ED game represents a realistic environment in which to practice decision making processes. The game presents players with a large number of possible actions at every point in game play. However, very few of those possible actions will benefit the teams' overall performance. In addition, the fact that a new event 'inject' occurred upon the deployment of any team means that unless this action is taken in a carefully planned manner, it has a chance of actually worsening the teams' position. Only a team that has shared all the relevant information and considered the potential consequences of all possible courses of action will consistently make decisions that are advantageous in the game environment.

The time allocated per each game round has also been carefully refined in order to maintain time pressure on participants' decision making. If teams consistently make inefficient use of resources under these time constrained conditions, they could be described as demonstrating faulty decision making processes. In order to evaluate whether that was the case, the efficiency of groups' decisions were measured by comparing each groups' final game score against the score that would have resulted from a group taking no actions. If a group obtained a worse score through taking actions than they would have obtained through taking no actions, then that groups' decision making process could be considered as faulty. Such a finding may also indicate that the group is suffering from the negative effects of stress and time pressure.

## 7.3 Research Question 2

The second method of evaluating whether groups' decision making processes were flawed and possibly influenced by stress is to examine the actions taken by each group in the final game round. Logically, it was not necessary for teams to take any actions in the final round. Event 'injects' were presented only at two points in game play; at the beginning of each round and also whenever a team was deployed. These events often had the effect of worsening the game state. If a group had not reached a casualty rating of 6 (thus failing the task) by the time the event inject had been presented at the beginning of the final game round, then the only way any further negative events could occur is through the deploying of teams. Thus, taking any actions in the final round could be considered unnecessary, while the deployment of teams in that round could be considered counter-productive and dangerous.

It must be noted here that the authors do not suggest that failing to take any actions is likely to be a successful strategy in dealing with emergencies. Rather, in the very particular context of the final round of the current game, that strategy is preferable. In effect, one of the aims of the game is to constantly require participants to sample the available information and evaluate what actions, if any, will lead to the best outcome.

## 7.4 Research Question 3

Finally, the literature has identified that decision making groups typically perform worse than their individual members would have on their own. In order to investigate whether this effect was also observed in the context of the DREAD-ED game, two participants were recruited and required to play the game individually. That is, the player controlled all four roles and determined how the resources flowed between all four teams. Results were then examined in comparison to group effectiveness.

# 8. RESULTS

The current analysis was focused on determining whether the challenges that are present in real world decision-making environments are also present in the game-world decision making environment. This was examined in terms of group effectiveness, the making of unnecessary and dangerous actions, and through examining individual versus group performance.

## 8.1 Group Effectiveness

In order to evaluate group effectiveness, the final score for each of the four groups was noted and compared with the game score that would have resulted if groups had not taken any actions over the course of the game session. This comparison is valid as the decks of cards from which all personnel and event cards were drawn, were arranged so that they were the same across all four groups.

**Table 1. The final game state for all four groups, plus the final game state for a hypothetical group that took no actions over the course of the game.**

| | Group 1 | Group 2 | Group 3 | Group 4 | No actions |
|---|---|---|---|---|---|
| Casualties | 5 | 5 | 6 | 5 | 4 |
| Hazard Risk | 3 | 3 | N/A | 4 | 5 |
| *Operations | 2 | 4 | N/A | 1 | 1 |
| *PR | 2 | 4 | N/A | 1 | 3 |

Table 1 presents the final game state for all four groups, plus the final game state for a hypothetical group that took no actions over the course of the game. It is important to note that for the casualties and hazard risk parameters, lower scores are preferable, while for operations and PR parameters, higher scores are preferable. From an examination of table 1, it appears that none

of the four groups that played the game suffered as few casualties as they would have suffered if they had taken no actions. A group that took no actions would have suffered a 'casualties' parameter increase from an initial starting value of 2 to a final value of 4 over the course of a game play session; whereas groups 1, 2 and 5 suffered an increase from 2 to 5. In addition, Group 3 suffered an increase in casualties from an initial starting value of 2 to a final value of 6, thus losing the game. This suggests that all four groups demonstrated ineffectual decision making processes.

## 8.2 Unnecessary and Dangerous Actions

As a further analysis of whether groups were lacking in sound group decision making processes, the number of actions taken in the final round of game play were examined. Because of the structure of game play, where injects only occurred at the beginning of a round and on deployment of a team, any actions in the final round could be considered unnecessary, while the deployment of teams in that round could be considered counter-productive and dangerous.

**Table 2. The number of actions taken by all four teams in the last round of game play**

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Number of actions taken in final round | 4 | 0 | 3 | 5 |
| Teams deployed | 0 | 0 | 1 | 1 |

Table 2 presents the number of actions taken by all four teams in the last round of game play. Only group 2 demonstrated an optimal strategy by making no actions in this round. Group 1 took a low-risk low-reward strategy by spending time exchanging team members but did not deploy any teams. Groups 3 and 4 displayed high-risk, low-reward strategies by deploying teams, an action that is necessarily followed by an event inject. Moreover, Group 3 actually reached a value of 6 on the Casualties parameter by deploying a team in the final round, thus failing the task set out at the beginning of the game. This analysis suggests that three of the four groups demonstrated inefficient decision making processes in the final round of game play.

## 8.3 Individuals vs. Groups

Research has identified that decisions made by groups are generally more problematic and less successful than decisions made by individuals [11, 23, 10, 9, and 22]. In order to examine whether this effect was also observed in the game, two participants were recruited and required to play the game individually. That is, the player controlled all four roles and determined how the resources flowed between all four teams. Participant 17 was previously a member of Group 2, the most successful decision making group. This participant was asked to come back to the lab three weeks after participation in the initial group trial. This participant was video recorded while playing the game, and the results of this game session are presented in Table 3.

Table 3 presents the results of participant 17s game session, both in terms of game success and the number of actions taken in the last round of game play. As predicted, participant 17 achieved a better game score while controlling all four roles concurrently than was achieved by the best group, Group 2. In addition, an effective strategy was adopted in the final round; that of taking no actions. When comparing the game score achieved by participant 17 with the hypothetical result of taking no actions, it appears that both scores are exactly the same. Thus, while this participant adopted a strategy that was preferable to that adopted by the group of which she was previously a member, this strategy was not a highly effective strategy.

It must be noted that, as Participant 17 had already played the game three weeks previously, it is unclear whether the score observed is due to the absence of other group members or simply due to practice at playing the game. In order to evaluate this, participant 18, who had not previously played the game as the member of a group prior to individual participation, was recruited.

**Table 3. Results of the game session played by participants 17 and 18, both in terms of game success and the number of actions taken in the last round of game play.**

| | Participant 17 | Participant 18 | No actions |
|---|---|---|---|
| Casualties | 4 | 5 | 4 |
| Hazard Risk | 5 | 1 | 5 |
| *Operations | 1 | 1 | 1 |
| *PR | 3 | 4 | 3 |
| Number of actions taken in final round | 0 | 3 | 0 |
| Teams deployed | 0 | 1 | 0 |

Table 3 displays results for participant 18. Similarly to participant 17, participant 18 achieved a better game score while controlling all four roles concurrently than was achieved by the best group, Group 2 (see table 2). However, an effective strategy was not adopted in the final round of game play. Specifically, this participant took three actions in the final game round, including the deployment of a team. In addition, participant 18 did not suffer as few casualties as would have been suffered if they had taken no actions at all. Thus, while this participant did not adopt a highly effective strategy, she still outperformed the best group.

In summary, it appears that groups who played the game demonstrated similar problems to those faced by real-world decision making groups. Actions taken were inefficient and sometimes dangerous. No group performed as well as the two participants who played the game individually. Moreover, neither groups nor individuals suffered as few casualties as would have occurred if they took no actions at all.

# 9. CONCLUSIONS

The current paper describes a game designed to function as part of a course to teach group decision making skills to emergency

managers. The design was informed by findings from the social psychological literature on the challenges faced by decision making groups. The analysis was focused on determining whether the challenges that are present in real world decision-making environments are also present in the game-world decision making environment. It appears that a lot of the defining characteristics of group decision making behaviour, especially the mistakes, are evident in groups that play our game. In addition, the round-based game structure allows a tutor the opportunity to deliver in-depth qualitative feedback without interrupting game play. Thus, the game design should prove to be a valid environment in which to train, practice and evaluate the decision making behaviours of groups and function as a valuable and engaging part of a group decision making skills training course.

All four groups in the current study demonstrated ineffectual decision making processes. Specifically, all four groups achieved a worse score through taking actions than they would have achieved if they had taken no actions. It appears that the game punishes inefficient behaviour. This finding appears to parallel real world circumstances, where taking ill-informed and unconsidered actions can lead to worse consequences than doing nothing. In addition, two of the four groups displayed dangerous behaviour in the final game round. Specifically, these teams took actions, the potential consequences of which had a high probability of being more detrimental to the game state than their action was beneficial. Teams should have identified at that point that only actions that could reduce hazard risk by 3 would be in any way appropriate in that round.

Across decades of research on group decision making, researchers have invariably found that groups who have not received appropriate training in decision making typically make worse decisions than would have been made by their individual members. In the current study, two participants were recruited in order to play the game individually. These participants played the game by assuming control of all four roles. Both of these participants outperformed the groups. Thus, it appears that the particular challenge presented by the game closely mirrors those presented in real-world situations.

It appears that the groups who played the game would benefit from training in sound group decision making processes, as envisioned for the wider training scheme. This training could help identify faulty processes that teams employed using examples from game play. These groups could then practice implementing the appropriate processes in the safety of the game environment. Importantly, as the game environment appears to replicate the features of a real-world decision making environment, any process gains achieved over repeated exposures to the game should transfer to real-world tasks. Whether this transfer does occur is an empirical matter that we will address with further work.

## 9.1 Future Work

The current study was conducted with a sample of convenience. Further work must be conducted on evaluating the game mechanics and overall training program with the target audience. It is possible that emergency management personnel may have a more advanced skill set than the current participants and would produce different results. This work is ongoing.

It must be noted that the current analysis is based on a co-located paper prototype, while the aim of the project is to develop a distributed multiplayer computer game. It may be necessary to refine some aspects of the game design in order to take into account the well documented differences between face-to-face and computer mediated communication (CMC). For example, CMC has been found to generate more equal participation of group members, greater information sharing, less normative influence, and ultimately better decision making than face to face communicating groups [25, 12]. However, there are also a number of disadvantages to CMC, including slower and asynchronous communication, decreased information flow and greater group conflict [28]. Indeed, these disadvantages may replicate some of the challenges that face emergency management personnel and cause similar levels of stress.

A huge advantage of the computerised version of the game over the current paper prototype will be the ability to analyse player data in real-time and provide informative in-game feedback to players on some aspects of their group decision making processes. For example, research has suggested equality of participation is a sound predictor of success in group decision making. The game itself could analyse the relative contributions of team members and present this data graphically to players in real-time. Interestingly, Group Decision Support Systems perform this very function and have been demonstrated to have positive effects on participant's decision-making behaviour [25, 4, 2, 12, 8, and 14]. However, this technology has not yet been implemented in game based training courses. If incorporated successfully within the game design, this technology has the potential to shape players' behaviour and reduce the workload of the tutor.

The current game design, when reproduced digitally, should provide a rich and engaging environment in which participants face exactly the same challenges that are faced in emergency management situations and where they can practice the skills of group decision making safely and with guidance from both a tutor and GDSS-style feedback. Crucially, these skills should then help emergency managers to make well-informed, rational and efficient decisions during the course of managing emergency responses to life-threatening events such as floods, fires, volcanoes and chemical spills.

## 10. ACKNOWLEDGEMENTS

This work was carried out as part of the "Leonardo" project "DREAD-ED: Disaster Readiness through Education" funded by the EU Lifelong Learning Program (see http://www.dread-ed.eu/)

## 11. REFERENCES

[1] Bogost, I. *Persuasive Games.* Cambridge, MA: MIT Press, 2007.

[2] Buder J., and Bodemer, D. "Supporting controversial CSCL discussions with augmented group awareness tools." *Computer-Supported Collaborative Learning, 3*, 2008, 123–139.

[3] Catania, A.C. *Learning* (4th ed.). Englewoods Cliffs, NJ: Prentice Hall, 1998.

[4] DiMicco, J.M., Pandolfo, A., and Bender, W. "Influencing Group Participation with a Shared Display," in *Proceedings of the 2004 ACM conference on Computer supported cooperative work*, 2004, 614 – 623.

[5] Ferster, C.B., Skinner, B.F., Cheney, C.D., Morse, W.H., Dews, P.B. *Schedules of Reinforcement.* New York: Appleton-Century-Crofts, 1957.

[6] Greitzer, F.L., Kuchar, O.A., and Huston, K. "Cognitive science implications for enhancing training effectiveness in a serious gaming context." *ACM Journal of Educational Resources in Computing, 7, 3*, Article 2, 2007.

[7] Habgood, M.P.J. *The effective integration of digital games and learning content*. PhD Thesis, University of Nottingham, UK, 2007.

[8] Hinds, P.J. and Bailey, D.E. "Out of sight, out of sync: Understanding conflict in distributed teams." *Organization Science 14,* 6, 2003, 615-632.

[9] Janis I. *Victims of Groupthink.* Boston, MA: Houghton Mifflin, 1972.

[10] Karau S.J., and Williams K.D. "Social loafing: a meta-analytic review and theoretical integration." *Journal of Personality and* Social *Psychology, 65*, 1993, 681–706.

[11] Kerr, N.L., and Tindale, R.S. "Group Performance and Decision-Making." *Annual Review of Psychology, 55*, 2004, 623–55.

[12] Kim, T.J., Chang, A., Holland, L., and Pentland, A. "Meeting Mediator: Enhancing Group Collaboration and Leadership with Sociometric Feedback," in *Proceedings of the ACM Conference on Computer Supported Cooperative Work. San Diego, CA*, 2008, 457-466.

[13] Koster, R. *A theory of fun for game design.* Scottsdale, AZ: Paraglyph Press, 2005.

[14] Leshed, G., Hancock, J.T., Cosley, D., McLeod, P.L., and Gay, G. "Feedback for Guiding Reflection on Teamwork Practices," in *Proceedings of GROUP'07, Sanibel Island, Florida, USA*, 2007, 217-220.

[15] Linehan, C., Lawson, S., and Doughty, M. Tabletop "Prototyping of Serious Games for 'Soft' Skills Training," in *Proceedings of 1st International Conference in Games and Virtual Worlds for Serious Applications 2009 VS-GAMES'09*, 2009, 182-185.

[16] Linehan, C., Lawson, S. and Doughty, M, and Kirman, B. "There's no 'I' in 'Emergency Management Team:' Designing and evaluating a serious game for training emergency managers in group decision making skills," in *Proceedings of the 39th Conference of the Society for the Advancement of Games & Simulations in Education and Training*, in press 2009.

[17] Loftus, G. R., and Loftus, E. F. *Mind at Play: The Psychology of Video Games*. New York, NY: Basic Books, 1983.

[18] Malone, T., and Lepper, M. "Making learning fun: taxonomy of intrinsic motivation for learning." In R. Snow, & M. Farr (Eds.) *Aptitude, Learning, and Instruction , vol. 3 of Cognitive and Affective Process Analysis,* 1987, 223-253, Hillsdale, NJ: Erlbaum.

[19] Siang, A.C., and Rao, R.K. "Theories of Learning: A Computer Game Perspective," in *Proceedings of the IEEE Fifth International Symposium on Multimedia Software Engineering*, 2003, 239-245.

[20] Skinner, B. F. *Science and Human Behavior* . New York: The Free Press, 1953.

[21] Skinner, B. F. *Cumulative Record* . New York: Appleton-Century-Crofts, 1959.

[22] Stasser, G., and Titus, W. "Pooling of unshared information in group decision making: biased information sampling during discussion." *Journal of Personality and Social Psychology, 48,* 1985, 1467–1478.

[23] Steiner, I.D. *Group Process and Productivity*, New York: Academic, 1972.

[24] Vorderer, P., Hartmann, T., & Klimmt, C. "Explaining the enjoyment of playing video games: the role of competition," in *Proceedings of the second international conference on Entertainment computing,* 2003, 1-9, Pittsburgh, PA, USA: Carnegie Mellon University.

[25] Watson, R.T., DeSanctis, G., and Poole, M.S. "Using a GDSS to Facilitate Group Consensus: Some Intended and Unintended Consequences." *MIS Quarterly, 12*, 3, 1988, 463-478.

[26] Woods, S. (2004). "Loading the dice: The challenge of serious videogames." *The International Journal of Computer Game Research , 4, 1*, Retrieved April 16, 2009, from http://www.gamestudies.org/0401/woods/.