Flood Management: A simulation and gaming perspective

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Abstract

While flood management is not a new phenomenon media interest into the effects has increased considerably in the past decades. Typical flood management strategies tend to be protective and dominated by engineering, scientific or technical methodologies. These include structural measures, for example, levees, floodwalls and dyke systems etc; and non-structural measures, for example, the utilization of forecasting systems, early warning systems, evacuation, flood plan development, flood insurance etc.

Although scientific and technical techniques have advanced, the losses of human lives and property have also increased. This paper will suggest to include more qualitative types of data in order to provide a balance approach to provide a balance approach to flood management strategies.

Response to floods, typically, involve a complex group of agencies, such as the emergency response organisations (police, fire brigades, and the ambulances), environment agency, water, gas and electricity companies, and voluntary organisations. These agencies normally response quickly and develop new ways to interact and communicate to each other. However, it is the crisis situation that these respective agencies cannot find a net work which leads to the collapse of the system.

It is argued that simulations could play a role in facilitating cross-agency integration and cooperation through a better understanding of the roles, capabilities and risk conceptions. Flood simulations, particularly those focus on crisis events, could improve the required skills: adaptability and coordination.

Flood simulation, however, has its potential problems. The first problem is representation (fidelity). The arguments focus on the necessity of running a verisimilitude simulation. Issues include the cost, time consuming, and effectiveness of conducting a real-world scenario flood simulation.

The second problem is the validation (assessment, evaluation) of simulations. It is difficult to measure how effectively an individual or an organisation applies the knowledge gained from simulations to real-world situations, given that there might be many differences between simulations and real-world scenarios, particularly in flood

simulations. Floods are not a unique phenomenon, however, their effects often are, it is therefore difficult to set up universal measurement criteria to evaluate the result of a simulation.

This paper attempts to address the following issues:

1. Advance our understanding of the context of flood management, including a critique of engineering, science, technically orientated prevention measures. An introduction of a socio-tech approach to flood management, and a highlight of the importance of flood simulations.
2. Synthesise preliminary findings of our research to consider how simulations and games could facilitate flood management for populations at risk.
3. Consider the extent to which a new methodology for conducting simulations is required.

Introduction

Typical flood management strategies tend to be defensive and dominated by engineering, scientific or technical methodologies (Smith and Ward 1998; Brown and Damery 2002); these include structural measures, for example, the utilization of forecasting systems (Cameron, Beven et al. 1999; Golding 2000; Monirul and Mirza 2002), levees, floodwalls and dyke systems (Montz and Gruntfest 2002; Evans, Penning-Rowsell et al. 2003) etc; and non-structural measures, for example, early warning systems (Faisal, Kabir et al. 1999; Fordham 2000; EnvironmentAgency 2001; Handmer 2001; McEwen, Hall et al. 2002); evacuation (Olsson and Regan 2001), flood plan development (Penning-Rowsell and Handmer 1988; Parker 1995; Gupta, Suresh et al. 2002), flood insurance (Arnell, Clark et al. 1984; Pynn and Ljung 1999; Burby 2001; Crichton 2003).

While scientific and technical strategies have advanced, the losses of human lives and property have also increased. In other words, that the risk of flood can be reduced but never eliminated through these approaches (Tobin 1995). Criticism of traditional flood management techniques have increased in the past few years (Parker 1995; Pielke 1999; Fordham 2000; Stoop 2003). It is suggested that social approaches should be embedded into flood management work (Green, Tunstall et al. 1987; Penning-Rowsell and Handmer 1988; Kirwan 2001).

Responding to floods, typically, involves a complex group of agencies, include emergency response organisations (police, fire brigades, and the ambulances), environment agency, water, gas and electricity companies, and voluntary organisations. However, these agencies tend to work separately and subject to their own mission statements. Although they quickly response and develop new systems of relations, information and interaction, if the multi-components cannot find a network, the system will collapse (Lagadec 1997), particularly in crisis situations.

It is argued that simulations could play a role in facilitating cross-agency integration and cooperation through a better understanding of the roles, capabilities and risk conceptions. Flood simulations, particularly those focus on crisis events, could improve the required skills: adaptability and coordination.

Flood simulation, however, has its potential problems. The first problem is representation (fidelity). The arguments focus on the necessity of running a verisimilitude simulation. Issues include the cost, time consuming, and effectiveness of conducting a real-world scenario flood simulation.

The second problem is the validation (assessment, evaluation) of simulations. It is difficult to measure how effectively an individual or an organisation applies the knowledge gained from simulations to real-world situations, given that there might be many differences between simulations and real-world scenarios, particularly in flood simulations. Floods are not a unique phenomenon, however, their effects often are, it is therefore difficult to set up universal measurement criteria to evaluate the result of a simulation.

This paper has three aims. First, to advance our understanding of the context of flood management, including a critique of engineering, science, technically orientated prevention measures. An introduction of a socio-tech approach to flood management, and a highlight of the importance of flood simulations. Second, to synthesise preliminary findings of our research to consider how simulations and games could facilitate flood management for populations at risk. Thirdly, to consider the extent to which a new methodology for conducting simulations is required.

Flood management

In the twentith century, the evolvement of flood management can be divided into three paradigms: the engineering paradigm, the behavioural paradigm, and the sustainment paradigm (Smith and Ward 1998). The engineering paradigm premises the flood hazards are caused by the extreme hydrological events; and therefore, the remedial measures are to apply physical control – structural measures - over flood flows. The behavioural paradigm can be traced back to White (1945) who was the first person to doubt the effectiveness of structural schemes in the US. His work is recognised as the 'Chicago School'. His work is based on the following statements:

1. The policy failure of the flood prevention authorities to consider the implementation of non-structural alternatives, such as land zoning or forecasting and warning.
2. The behavioural failure of individual floodplain managers and residents to assess the full risk from flood.

(Smith and Ward 1998)

This approach is so called non-structural measures which depends on certain appropriate techniques, such as advanced communication system and accurate mapping techniques (Smith and Ward 1998).

The sustainment paradigm considers the public should participate in the contingency/disaster planning process. In addition, it also hightlihgts the necessity of considering flood management in a context of world wide sustainable development.

The following sections will display the basic ideas of these three paradigms.

1. The engineering paradigm – structural measures

Structural flood defence is applied as a mitigation and protective measure which has been dominant all over the world. It is based on the model of flood control (Brown and Damery 2002). Examples of structural measures include: (1) levees or walls to prevent incubation from floods; (2) diversion structures to divert flow during the peak from the protected region; (3) channel modifications to increase the hydraulic capacity or stability of the river; and (4) one or more reservoirs upstream from the protected community to capture the volume of a designed flood and release it at non-damaging rates (Petak and Atkisson 1982; Handmer 1987; Parker 1995; Smith and Ward 1998; Simonovic 1999; Wohl 2000).

Other abatement methods are also applied to mitigate the damage of potential flooding. For example, topographic modification – including terracing and contour ploughing, surface and underground water storage, and gully control. In the perspective of vegetation modification, grassland, crop and forest cover methods are applied (Smith and Ward 1998).

2. The behavioural paradigm – non-structural measures

To improve flood mitigation strategy, a behavioural paradigm which comprise the idea of non-structural measures has been considered (Penning-Rowsell and Handmer 1988). It is argued that non-structural measures are more acceptable to the public in terms of environmental perceptive. Moreover, it is less costly than traditional structural solutions (Brown and Damery 2002).

Non-structural measures emphasise (1) flood warning systems: including weather forecast system (Golding 2000; Alcantara-Ayala 2002), and the predict of flood magnitude and frequency; (2) 'zoning': using the mapping techniques to distribute the flood plane areas (Penning-Rowsell and Handmer 1988; Parker 1995; Gupta, Suresh et al. 2002); (3) protection of individual belongings (Parker 1995; Simonovic 1999): for example, waterproofing of the lower floors of existing buildings; (4) flood insurance (Arnell, Clark et al. 1984; Pynn and Ljung 1999; Burby 2001; Crichton 2003): provide compensation when damages are not preventable at adequate cost; and (5) evacuation: evacuate residents and move valuables (Faisal, Kabir et al. 1999; Fordham 2000; EnvironmentAgency 2001; Handmer 2001; McEwen, Hall et al. 2002).

3. The sustainment paradigm – total disaster management

In the 1980s, scholars advocated an emergency life cycle with a number of defined stages, these include, mitigation, preparedness, response and recovery (Public Administration Review 1985).

The 'mitigation' stage, is concerned with identifying and determining the potential risk to the health and safety should be. Consequently, it often takes the form of a risk reduction program.

The 'preparedness' stage, typically involves constructing a response or contingency plan in order to minimize potential hazardous effects. The plan is concerned with the identification of critical resources and the development of necessary agreements among responding agencies. This might also involve training first responders to save lives and reduce disaster damage.

In the 'response' stage, the focus moves to providing emergency aid and assistance. Emphasis is also placed on reducing the probability of secondary damage, and minimize operational recovery problems. The 'Blue light' services - police, fire and ambulance, should be responsible for this stage.

Finally, the 'recovery' stage not only provides support during the early recovery period, but continues until the community has returned to normal. Insurance, therefore, would be a crucial issue in this stage (Fordham 2000).

It is argued that the application of this 'emergency life cycle' can achieve a total/holistic disaster risk management because it provides a better understanding of the nature of disasters, decrease their harmful damages, and prevent the reoccurrence of the disasters as well (McLoughlin 1985; Plate 2002; de Guzman 2003).

Criticisms

Criticism of traditional flood management techniques have increased in the past few years (Parker 1995; Pielke 1999; Fordham 2000; Stoop 2003).

In the perspective of structural flood measures, people tend to construct more structural measures to build a safer society and they progressively build higher levels of structural flood defence to ‘protect’ potential flood damages. This phenomenon is associated with the ‘escalator effect’ (Smith and Ward 1998). However, it is argued that structural flood defences can never totally 'prevent' flooding (Parker 1995; EnvironmentAgency 2003). According to Tobin (Tobin 1995), levees can actually increase the potential for flood losses. The 'levee effect' could even increase society's vulnerability by creating a sense of complacency which leads to reduced preparedness and a lack of incentives to build more defence structures.

Non-structural measures rely on mathematical approaches to predict or calculate potential damage. It is argued that quantitative methods may standardize operational procedures, and provide a legal status. It also creates an apparent 'objective' system. However, QRA have their own boundaries. The validation of quantitative risk assessments (QRA) has been doubted.

QRA techniques are potentially limited by the change of the weather or land use (Green, Tunstall et al. 1987). The parametric uncertainty and systemic uncertainty also reduce validity[1] of QRA (Green, Tunstall et al. 1987; Stoop 2003). For example, flood frequency. Pielke indicates that either 50 or 100-year flood standard has some potential errors because this standard is based on past flood records, and therefore it is subject to the past history. With the development of flood plan or human behaviours, the results of probabilities of future floods is modified (Pielke 1999; Poff 2002).

Lastly, the command and control models in the emergency management is also criticised. It is argued that this para-military approach simplified the complex social reality. In addition, this inflexible, bureaucratised structure cannot meet the requirement in a real hazardous event (Comfort 2000). Consequently, a bottom-top model is recommended (Fordham 2000). The development of a comprehensive flood management plan involving all levels of government and local communities is suggested as well (Simonovic 1999).

Due to the weakness of the traditional food management, research should broaden its scope to include studies of the social impacts of floods and flood mitigation schemes (Penning-Rowsell and Handmer 1988). It is suggested that social approaches should be embedded into flood management work (Green, Tunstall et al. 1987; Penning-Rowsell and Handmer 1988; Kirwan 2001)

A System Perspective to Flood Management

It is suggested that new techniques and theories of risk analysis and decision-making need to include more qualitative types of data in order to provide a more balanced

[1] Parametric uncertainty means that inherent inaccuracies caused by measurement error or data availability. Systemic uncertainty refers to the degree of the conditional probabilities in a model.

approach to risk (Turner 1978; Pidgeon 1988; Toft 1992; Borodzicz 1997) and one alternative method is system theory. It is argued that an understanding of system theory contributes to proactive risk management. Consequently, it also provides a more balanced approach to flood management.

Turner has argued that the majority of large-scale accidents are caused by a combination of individual, group, social and organisational factors. Only on the odd occasion are disasters caused by technical factors alone (Turner 1978).

Using Bertalanffy's (1968) system theory, different systems may have different appearances, but display the same or similar characteristics intrinsically. In other words, if different systems have the same or similar components, they may have similar failures. Walsh and Healey argue that 'disasters' continue to be replicated simply because each time little is learnt from them.

> "The occurrence of a disaster usually overwhelms those affected by it when there has been no planning or preparation. Even in situations that are repetitions of previous calamitous events, people often seem to be unprepared. The annual flooding of certain rivers offers a prime example of this category. Residents will repeatedly be devastated, but each time be no better equipped than the time before."
>
> (Walsh and Healey, 1987: 10.1)

In Perrow's (1984) 'normal accident' theory, he indicated that when a system becomes tighter and more complex, it will fail:

> If interactive complexity and tight coupling - system characteristics - inevitably will produce an accident, I believe we are justified in calling it a normal accident, or system accident. The odd term normal accidents is meant to signal that, given the system characteristics, multiple and unexpected interactions of failures are inevitable. This is an expression of an integral characteristic of the system, not a statement of frequency.
>
> (Perrow 1984:5)

Responding to floods involves a complex group of agencies, ranging from environment agencies, water companies, emergency services, volunteer groups and communities (HampshireCountyCouncil 2001; CabinetOffice 2003). When a flood occurs, the emergency response system quickly displays a tight and complex characteristic.

However, these agencies tend to work separately and are dependent on their own operational procedures. Although they quickly response and develop new systems of relations, information and interaction, if the multi-components cannot find a network, the system will collapse, particularly in crisis situations (Lagadec 1997).

In crisis situations, response teams typically face the following problems: (1) ill-structure (Perrow 1994; Borodzicz 1996); (2) dynamic environments (Fordham 2000); (3) shifting or competing goals; (4) time stress (Fisher 1996); and (5) high stakes (Lagadec 1997; Wybo and Lowalski 1998; Oser, Gualtieri et al. 1999; Dobson, Pengelly et al. 2001; Schaafstal, Johnston et al. 2001). These problems prevent decision-makers from communicating and disseminating decisions, as well as coordinating with the other agencies.

It is suggested that crisis simulations can help to improve the emergency response performance in terms of cross-agency communication and coordination through understanding each other's tasks and goals (Kaplan, Lombardo et al. 1985; Lagadec 1997; Carrel 2000; Dobson, Pengelly et al. 2001; Borodzicz 2002). Effectiveness training environment could help to develop and maintain team performance or competencies, for example, knowledge, skills, and attitudes (Ford and Schmidt 2000).

Learning Theory to Simulations

There is a trend to use learning theory as a means to explain and evaluate the process and result of simulations. Scholars use three dimensions to examine learning process and learning results: the individual learning (Piaget 1972; Kolb 1984; Stern 1997), team learning (Bolstad and Endsley 1999; Langan-Fox, Wirth et al. 2001), and organisational learning (March 1991; Romme and Dillen 1997; Huysman 2000; Molleman and Broekhuis 2001; Williams 2001).

From the individual perspective, it is believed that simulations can improve mental models (Pidgeon, Hood et al. 1982; Richards 2000; Dobson, Pengelly et al. 2001). A mental model is 'a representation of an individual's perception of the world and ways of using this knowledge' through techniques such as interpretations, communications, and behaviour (Pidgeon, Hood et al. 1982; Dobson, Pengelly et al. 2001).

Learning does not only occur in individual level, the team or group has gradually replaced the individual as the essential learning unit (Senge 1990). In a dynamic and competitive environment, inter-organisational departments are the best learning units (Stern 1997; Bolstad and Endsley 1999; Stern and Sundelius 2002).

Through team mental models, which are comprised of shared mental models (Crookall, Oxford et al.; Espinosa, Carley et al. 2001) and team situational models (Langan-Fox, Wirth et al. 2001), it is easier to understand the other people's tasks and their responsibilities. It helps multiple emergency teams to manage their interdependences more effectively (Dobson, Pengelly et al. 2001; Espinosa, Carley et al. 2001).

The focus of organisational learning is on the nature/process of learning in an organisation; therefore, it tends to be more descriptive and analytical (Tsang 1997; William 2001; Sadler-Smith 2001). The term organisational learning can be further defined as 'changes in the organisational knowledge and enable an organisation to find new ways in order to survive in new' (Klimecki and Lassleben 1997).

However, there are still considerable controversies regarding what organisational learning can do. Debates about this question should be categorized in terms of 'Who learns?', 'How do they learn?', 'When do they learn?', and 'Why do they learn?' (Huysman 2000)

In the first place, organisational learning is seen as a process of reconstructing organisational knowledge. While organisational knowledge includes shared values, stories, practices, meanings, beliefs, etc. Debates focus on could these collective results be learnt (Dogson 1993, 377; Huysman 2000).

The second argument is based on the assumption: learning should be voluntary, and the learning processes should be mutual. It is questioned that if organisational learning and individuals in an organisation are voluntarily socialised to organisational beliefs (Romme and Dillen 1997).

Thirdly, the dispute focuses on if learning process is planned for or contingency. It is argued that although most learning processes within organisation are planned for, some learning processes might be unplanned or unnoticed by the actors involved (Pedler, Burgoyne & Boydell 1991; Garvin 1993; Senge 1990).

The last debate focuses on positive and negative learning results through examining learning process and outcomes. There is no reason to learn if the result is negative (Levinthal & March 1993; Tsuchiya and Tsuchiya 1999).

Though there are still some controversies in learning theory, it is argued that simulations provide a good learning environment for participants as an effective means of improving future job performance.

Simulation

Definitions

A simulation can be defined as a representation of the real and dynamic reality to achieve a particular goal or process or environment (Kleiboer 1997). Modern simulations are applied to various aspects of our lives. Simulation is also a common method used by emergency services to facilitate cross-agency communication and coordination through a better understanding of roles and capabilities (Kaplan, Lombardo et al. 1985; Borodzicz 1997; Dobson, Pengelly et al. 2001). The range and scope of simulations, however, lead to a difficult theoretical and practical problem. It is necessary to distinguish different purposes of simulations.

Purposes

Most simulations lack purposes and it is suggested that when designing a simulation, it is crucial to 'clarify goals' in the first stage (Turner 1996). In this stage, different scenarios and threats should be identified. For emergency service organisations, the definition of risks, crisis, and disasters should be distinguished in the first instance. Understanding these differences facilitates the development of more focused training programmes for key decision makers (Borodzicz 2002).

For emergency services, each agency sets up its own standard operating procedures. In normal events, there is no problem to implement these procedures. However, it is the abnormal situations that require a more precise and adaptive action. During a crisis, limited time and information overload prevents decision-makers from communicating and disseminating decisions. The purpose of a crisis simulation for emergency response teams is to train the adaptive experts to identify and apply the necessary response to a crisis, given that they might face numerous unpredictable and uncertain events (Ford and Schmidt 2000; Wilson 2000).

Most flood simulations (drills, exercises, and training programmes) are aimed at improving skills in dealing with normal events (FEMA 1996; MajorEmergenciesCo-ordinationCommittee 2000), and also test the operational procedures for normal events (HampshireCountyCouncil 2001; SchotischExecutive 2001). These trainings are not sufficient when confronting crisis events. In order to achieve a more efficient emergency response team, it is necessary to explore the context of crisis simulations when dealing with floods (Drabek 1985; Ford and Schmidt 2000; Crichton and Flin 2001).

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The difference between crisis simulations and other types of simulations is to improve the abilities of decision-makers to deal with crisis events. It is, therefore, the ability of an expert to transfer knowledge, skills and attitude in actual emergency situation become a significant issue in the crisis simulation.

Building up an expertise emergency team

Hence, when establishing an expert emergency team which involves multiple organisations to dealing with crisis events, it is necessary to consider the following two skills: (1) adaptability: the ability to decide and take appropriate strategies in a short time to deal with crisis ('t Hart 1997; Flin 1998; Borodzicz 2002); (2) coordination: the ability to work with the other team members; and also, with other teams (Lagadec 1997; Wybo and Lowalski 1998; Ford and Schmidt 2000; Dobson, Pengelly et al. 2001; Schaafstal, Johnston et al. 2001; Stoop 2003).

Through analysis task work and team work, it is clearer to know the way to improve these two skills – coordination and adaptability.

1. Task work

Task work skills are related to the execution of the task at hand (Ford and Schmidt 2000). Usually individual expertise is used to explain the content of task work. Expertise can be classified into two groups: routine and adaptive expertise. Routine experts are familiar to reoccurring events; however, they are not able to handle novel or new problems and situations.

In contrast, those adaptive expertises should be good at generating creative solutions to crises. They are more likely to 'stretch' their knowledge and abilities to deal with new problems and situations.

Because of complexity and dynamic characteristics of crisis, emergency response experts must dynamically assess and regulate their solution strategy (Cannon-Bowers, Tannenbaum et al. 1995; Oser, Gualtieri et al. 1999; Ford and Schmidt 2000). This is the knowledge, skills and attitude, or ability that an expert need to obtain in actual emergency situation (Molleman and Broekhuis 2001).

Most emergency response trainings tend to focus on the individual skills; however, it has became more important to stress on the interpersonal and system competencies for effective and individual and team performance (Ford and Schmidt 2000).

2. Teamwork

Teamwork refers to the interaction among team members, largely independent of the task to be performed. Research suggests that teamwork skills are a critical determinant of team performance, particularly those teams under high stress, for example, emergency response teams.

The distinctions of expert and novice in teams can explain the content of teamwork:

> (1) The information exchange dimension: seeking information from all available sources, passing information before being asked for it, and providing 'big picture' situation updates.
>
> (2) The communication dimension: providing complete, concise, properly stated communication reports.
>
> (3) The supporting behaviour dimension: correcting team errors, and providing and requesting backup or assistance when needed.
>
> (4) The team initiative/leadership dimension: providing guidance and support to team members, and stating clear team and individual priorities
>
> (Schaafstal, Johnston et al. 2001)

In this circumstance, crisis simulations not only improve individual's skills, but also enable participants to work with each other in a crisis atmosphere in which unfamiliar events and stresses occur. Extra-organisational coordination/communication could be taught in this context as well.

Eight Rules for simulation design

Simulation designers should focus on implementing training to support the acquisition, development, and transfer of competencies necessary for effective performance (Schaafstal, Johnston et al. 2001). It is suggested that elements such as planning, preparation, execution, analysis, performance measurement, and feedback (Oser, Gualtieri et al. 1999; Borodzicz and van Haperen 2003) should be considered while designing a simulation.

Designing an effective simulation does not have a single set of rules. It depends on the context of their use: what is the main purpose, who are the participants, how much time and resources are available? Loveluck (1994) illustrated eight elements that should be considered before designing a simulation:

> ' 1. Simulation should display an external simplicity which masks their internal complexity.
> 2. Games should have some theoretical underpinning.
> 3. Games should contain 'an element of surprise'.
> 4. The social structure of the group of players may conflict too strongly with the desired players and also the desired power structure in the game.
> 5. In management training, 'verisimilitude' is valued more highly than realism.
> 6. There is a difference between running and merely administering a game.
> 7. Games are culture sensitive.

8. All simulation games will display 'an emotional impact'.'

(Lovelock 1994)

Problems in Simulations

Simulation has its potential problems. The restrictions for emergency service teams to conduct a simulations are limit time and funds. Besides, the main problems for crisis simulations are the degree of representation, and the lack of valid and reliable performance measurements.

Fidelity

The first problem is representation (or fidelity). Fidelity is the level of authenticity that a simulation represents to the participants. Representation could be one of the central features of simulations because it relates to the similarity to the operational situation. According to Bagdonas , Patasiene et al. (Bagdonas, Patasiene et al. 2002), representation has the following properties:

'1. Anything can be a representation of anything. That anything has a desired number of properties, and it can be represented in any way.
2. The individual decides what is a representation of that other something. If he/she does not think so, it is not a representation of that something. Thus, representation is the creation of reflections/images.
3. During representation we compare at least two objects, phenomena or its properties.
4. Anything is not a representation of itself.'

(Bagdonas, Patasiene et al. 2002).

Some scholars argue that the more accurate the real world scenario (mimicking, verisimilitude) is represented in a simulation, the more effective the results (Feinstein and Cannon 2002).

In contrast, other scholars indicate that similarity to real-world scenarios is not necessary for learning and may actually inhibit skill acquisition for naïve learners (Nudell and Antokol 1988; Stuart 1998; Stolk, Alexandrian et al. 2001). Similarly, these studies also found that low fidelity exercises can assist in obtaining details of training and education. For example, Dobson suggests a 'parsimonious' or 'specific' level of representation (Dobson, Pengelly et al. 2001).

Scholars indicate that similarity to real-world scenarios (mimicking, verisimilitude) is not necessary for learning and may actually inhibit skill acquisition for naïve learners (Nudell 1988; Dobson, Pengelly et al. 2001), although some scholars argued that the more accurate the real world scenario is represented in a simulation, the more effective the results. Dobson suggested a 'parsimonious' or 'specific' level of representation (Dobson, Pengelly et al. 2001) is a better method to design a simulation. Other scholars, such as Feinstein (2002), also pointed out that 'lower fidelity' can help to obtain the purpose of simulations.

Validation

The second problem is the validation (assessment, evaluation) of simulations. As a result of the complex type of social, cultural and psychological phenomenon associated with these simulations, evaluation is problematic. Evaluation or assessment is a process of 'collecting, describing, scoring, and interpreting information about individual learners or groups' (Knippenburg-Gillis 1996: 117, quoted in Borodzicz 2002). It is used to evaluate the effectiveness of the instruction and learning.

The breadth, depth and type of expertise highlight the complex dimensions when designing a simulation. Consequently, it is difficult to measure how effectively an individual applies the knowledge gained from simulations to real-world situations, given that there might be many differences between simulations and real-world scenarios, particularly in emergency management. Ford et al. (Ford and Schmidt 2000) indicated three types of challenges in transfer problem: (1) retention of training knowledge and skills over time; (2) effective generalization of skills learnt in training to the significantly different demands that could arise in an actual crisis, and (3) effective assimilation of individual efforts into a coordinated crisis response.

Thus, transferring knowledge or skills gained from simulations to the real world could challenge crisis simulation design (Ford and Schmidt 2000). Thorndike (1903) indicated that positive transfer could occur if there are specific elements in the training task which are the same as original (Borodzicz 1997).

Debriefing

Debriefing is a common means to evaluate the result of simulations. It helps participants to reflect on their simulation experience and to learn transferable skills and concepts (Thiagarajan 1993). It is therefore necessary following a simulation. Participants should reconstruct the whole scenario during the simulation in order to gain insights and proper skills into the team (Kaplan, Lombardo et al. 1985; Kleiboer 1997; Lagadec 1997; Borodzicz 2002; Borodzicz and van Haperen 2003). From Crookall and Saunders' point of view, a simulation is fundamentally a learning exercise. Participants learn from being involved in that dynamic simulated reality.

Debriefing also provides a good opportunity for participants to avoid learning disturbances in the simulation (Romme and Dillen 1997). In the case of situational learning, it occurs if the participants do not secure their knowledge or forget to code it for later use. Another kind of learning disturbance is fragmented learning. It takes place when individual mental models and team mental models are poorly maintained (Romme and Dillen 1997). Listing drawbacks in the design of debriefing process, they could help to avoid learning disturbances (Coote and McMahon 1988).

However, it is argued that, in emergency response simulations, participants sometimes regard the drills as an examination of their personal abilities; however, this could lead to a bad outcome, particularly in the process of debriefing (Hill and Lance 2002). These highlight the importance to design a well structured debriefing procedures.

Conclusion

Modern options for flood management are not absolute. The strategies to deal with floods varies over time and space. However, the aim of protecting society and security remains. It is suggested that a better understanding of flood management should not only concentrate on technical and quantitative points of view, but social science persectives. Much research finds that the majority of large-scale accidents are caused by a combination of individual, group, social and organisational factors, and rarely caused only by technical factors (Turner 1978). It is, therefore, argued that working together can produce more balanced results. Research should broaden its scope to include studies of the social impacts of floods and flood mitigation schemes (Penning-Rowsell and Handmer 1988).

In this paper, it is suggested that simulation is a good way to train related personnel to posses certain abilities in dealing with floods. Simulations should focus on certain purposes to improve expertise and facilitate the effectiveness in response to disasters. The demand on flood scenarios have rapidly grown in recent years due to the increasing numbers of flood events. To sum up, this is the right time to consider manipulating a better flood simulation.

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