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A PLAYFUL APPROACH TO FLOOD DEFENCE

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ABSTRACT: Floods are natural and devastating disasters that do not occur that often and when they do, they happen unexpectedly. This characteristic makes it difficult to be prepared for these types of disasters. Situations cannot be trained and measures can hardly be tested. This paper looks into how games can assist in this particular problem for flood defence. It is suggested that games provide compelling, experiential, authentic and safe environments that differ from other frequently used tools, like Decision Support Systems and simulations, in the role of its users and the outcomes. The use of gaming has an educational value that consists of the acquisition of elaborate mental models and increased awareness, and an organizational value composed of the game becoming a knowledge repository, providing a shared and explicit vision, and stimulating discussion. These ideas are supported and illustrated by the results of *Levee Patroller*, a game developed to train professionals the required skills to inspect levees.

Key Words: flood management; serious gaming; training.

1. INTRODUCTION

Floods are natural and devastating disasters. Worldwide people and their livelihoods are affected by the consequences of these water-related hazards. The most recent events concern the Tsunami in 2004, hurricane Katrina in 2005 and the floods in the United Kingdom during the summer of 2007. The past has shown that measures can be taken against flooding. Between the years of 1750 and 1800 evidence exists of 152 floods in the Netherlands (Ras & Vogelaar, 2004). In 1798 the Directorate General for Public Works and Water Management was founded and from that point on fewer problems have taken place. This indicates that investing in flood defence does help. Nonetheless, failures kept occurring in the Netherlands, for example in 1953. The problem with floods, and with disasters in general, is that when basic precautionary measures have been taken, they do not occur that often. And when they do, they do so unexpectedly together with many factors, situations and other relevant characteristics that have not been thought of upfront.

Another reality in today's world is the pervasiveness of games. They are literally everywhere. It is possible to see people playing games on their mobile phones, on the streets with their portable handheld computers, and of course at home. Although some dismiss games as playful, and therefore as trivial, this playfulness can actually be a useful characteristic for decision making, management and other *serious*

activities (Johnson, 2005). For instance, in games such as *Civilization* and *SimCity*, players learn to manage respectively civilizations and cities. It gives them a feeling – a *sense* – of the wide variety of options (and their consequences) of how to deal with certain problems. The *mental model* players acquire through playing may help them outside the game environment; in dealing with "real" problems.

With this in mind, it is just a few steps away to connect gaming with flood defence. A field has arisen, the field of *serious gaming*, that actually tries to bridge the world of gaming with "serious" activities, such as politics, policy, healthcare, and so on (Michael & Chen, 2006). Many "serious games" have already been developed, like *Peacemaker*, a game about the Israeli-Palestinian conflict, and *Virtual Leader*, a game about training leadership skills. This paper sheds light on how games could be of benefit to flood defence. In discussing this issue, this paper looks into what serious games are in Section 2, describes how they can be useful for flood defence in Section 3, and gives an example of an application called *Levee Patroller* in Section 4.

2. SERIOUSLY PLAYING

Games have an actual long history of being directed at serious purposes. In ancient times people enacted scenarios of catching wild animals to practice their hunting skills. In Medieval times *Chess* was used to get insight about different strategies of how to make war. Nowadays, a variety of serious purposes are being explored by using games, from politics to advertising (Michael & Chen, 2006). The umbrella term for games that are used for non-entertainment purposes is "serious games". To understand what serious games are, it is important to first of all understand what games are and how they differ from other frequently used tools in flood defence; Decision Support Systems (DSSs) and simulations. This is discussed in Section 2.1. Subsequently, Section 2.2 explains how a serious game differs from an entertainment game and why many researchers and practitioners are considering them.

2.1 Games vs. Decision Support Systems and simulations

Games can be seen as rule-based systems with variable outcomes that players can exert influence on by manipulating the rules (Juul, 2005; Salen & Zimmerman, 2004). This definition shows that games are close relatives to DSSs and simulations. Nonetheless, a first and foremost difference is the inclusion of *humans* (i.e., the "players") during the calculation processes. In most DSSs and simulations human interaction is reduced to ex ante configurations of the model, like setting parameter definitions. Whenever models require human input at more than one moment, they become much more "game-like".

To be even more game-like, this human input needs to be part of the system; in games users are participants. Users have to understand and act upon the rules of the system to achieve their goals. In contrast, with DSSs and simulations users are not part of the system; they are observers. For people working with DSSs and simulations the system is a black box (unless they have built it themselves). They "observe" an input and output and can only make educated guesses of what happened in between. Users of DSSs and simulations are therefore more distanced from the application than users of games.

Another difference concerns the *outcomes* of these tools. For DSSs and simulations, the outcomes are the primary purpose of using them. They are used to make an informed decision or to make an elaborate analysis. For games, the process of getting to the outcomes is just as (or even more) important. It is for example relevant to think about why a player made certain decisions and what caused him to do so. For DSSs and simulations the process characteristics are only relevant to consider the limitations of the results. For example, the assumptions behind the models, such as how water flow is depicted, are important to take into account when interpreting the results.

Besides the importance, the outcomes of DSSs and simulations are precise and specific, whereas the outcomes of games are vague and broadly applicable. Games focus much more on higher-level system aspects and less on the details, while the reverse is true for DSSs and simulations. For instance, a game

could be about understanding how a water system works and a DSS or a simulation about calculating the amount of water flow. The outcomes of the first are much vaguer and broadly applicable than the latter.

Of course, these differences of human input and outcomes between games on the one hand and DSSs and simulations on the other have to be taken with a grain of salt. Many cases exist that are difficult to categorize. These types are sometimes labeled “Decision Support Games” or “simulation games”. Nevertheless, for understanding how games can be beneficial to flood defence it is relevant to contrast them to other widely used tools in this area. The earlier mentioned differences may help in achieving this.

2.2 Serious games unraveled

Serious games distinguish themselves from their entertainment counterparts in that they serve some non-entertainment purpose, whether this is educational, political or something else (Michael & Chen, 2002). This has two implications. First, the playing experience has to be *meaningful*. The experience should go beyond the game and have effects on thought and/or behavior outside the game environment. Second, since the experience should affect reality, it should have some *validity*. Without it, the changed thoughts and/or behaviors are not desired or are of limited use in the real world.

All of this does not mean that serious games should be non-entertaining. Despite the emphasis on non-entertainment, another aspect of this field is that it tries to learn from the entertainment games industry. Children, but also mothers and fathers are hooked for hours and hours to their games. This engagement that entertainment games offer, has to be included in some sort of way into serious games as well. Otherwise users will not be motivated to play the game or will only consider it for a slight moment. For this reason, serious games have to be *fun* next to meaningful and valid.

The above explains what serious games are or rather what they ought to be. However, it does not explain why researchers and practitioners are considering serious games. The list below gives some of the most frequently mentioned reasons (Gee, 2003):

- *Experiential* – Games are not passive media, like TV. They require an active attitude and let its users engage with the material;
- *Safe* – Games let their users experience situations without any real world consequences. Users can always “try again”;
- *Authentic* – Games, especially digital ones, make it possible to (re)create compelling audiovisual environments. They also make it possible to create non-existing or rare situations;
- *Motivating* – Games are fun and challenging. Together these elements ensure that users keep playing.

Some may also mention that games are relatively inexpensive. This reason is not included in the above-mentioned list as the development costs and the required amount of expertise to develop a game should not be underestimated. Next to this, we are of the opinion that games should not replace previous practices. They should be a welcome addition or an improvement on top of previous practices.

3. VIRTUAL FLOOD DEFENCE

By taking the characteristics of serious gaming from Section 2 into account, this Section looks into how serious gaming could be beneficial to flood defence. Flood defence can be considered a subset of disaster management that specifically addresses water-related hazards. Like its parental node, flood defence shares with disaster management the cycle of mitigation, preparation, response, and recovery (see Figure 1). In every part of this cycle serious gaming can play a role. This role can have two distinct

values, an educational and/or organizational value. The first value is discussed in Section 3.1, the second in Section 3.2.

3.1 The educational value

The best way to point out the beneficial role of gaming is to again look at the use of DSSs and simulations and by considering how these tools can be related to the disaster management cycle of Smith (1996), which consists of three large cycles: Assess, prescribe and educate (see Figure 1). Although overlap between these tools and the different phases of the cycle exist, fundamentally simulations are used to “assess” and DSSs to “prescribe”. Games can be used for the remaining phase, to “educate”. This education should not be thought of in a narrow sense, such as in formal schooling. It should be thought of as a way for people to experiment with measures (and evaluate them), to practice rare and unexpected situations, and to bring awareness.

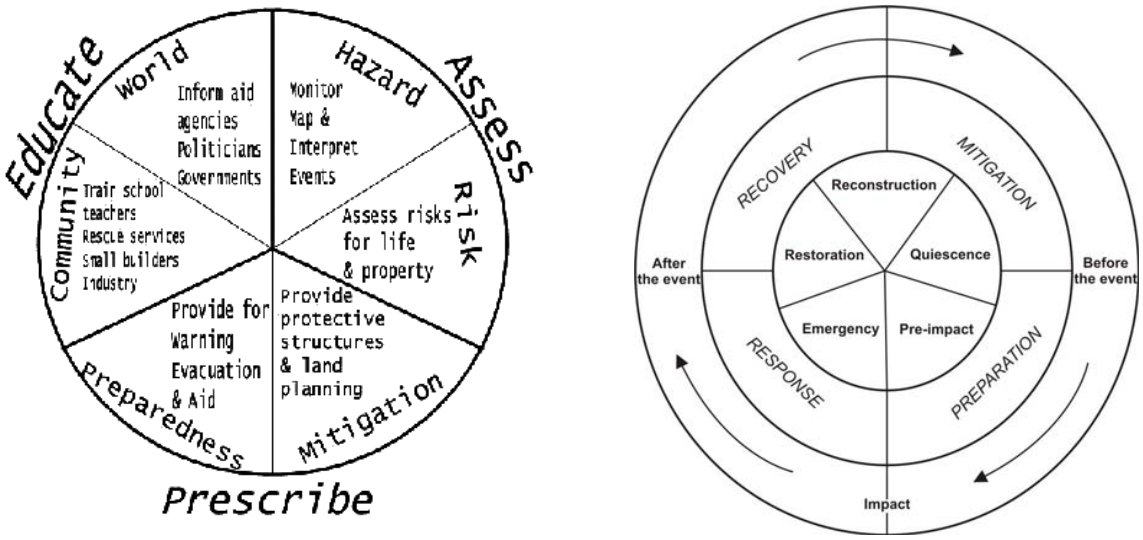

Figure 1: Disaster Management Cycles (left, Smith. K, 1996; right, Alexander, 1993)

For professionals dealing with floods on all levels, from the operational to the managerial level, this education through games is helpful as failures do not occur that often and the virtual environment of a game makes it possible to practice these situations. Managers can train their decision making knowledge and skills, while professionals can train recognition and procedural knowledge and skills. For both, it is important that this practice leads to the development of elaborate mental models. Such models are important according to the psychologist Klein (in Weick & Sutcliffe, 2003). He suggests that the most effective fire commanders have rich fantasy lives and mentally simulate potential lines of attack. This ability to mentally simulate possible situations is probably equally relevant for professionals involved with flood defence.

Another reason why games can be important educational tools is that they test simple sets of expectations. If professionals depend on these, unusual events can develop to more serious levels before they even noticed them (Weick & Sutcliffe, 2003). To weaken the grip of this invisible hand of expectations so professionals can see more, make better sense of what they see, and remain more attuned to their current situation, games can be used. When professionals have a wrong or a simple set of expectation, they will undoubtedly make mistakes and the game will immediately provide feedback about these. This feedback enables those professionals to understand the consequences of their actions and may lead them to revise their mental models.

Hence, games could encourage people to be self-conscious about the validity of their beliefs and to question them, reaffirm them, update them, replace them, besides learning from the gaming activity itself. As such, games induce a state of *mindfulness*. This is a state in which a person is open to new information, continuously refines and differentiates expectations based on newer experiences and has an implicit awareness of more than one perspective (Langer, 1997; Weick & Sutcliffe, 2003). Therefore, the educational value of games is not only hidden inside its messages of transferring specific knowledge and skills, it also provides a way of thinking and a situational awareness of a crisis situation. In other words, by playing games professionals could get a better sense of their environment and how to act upon it.

For the general public, games may be used to inform, create awareness or to relief people from a flood. Informing and creating awareness could consist of a game that tells people what to do if a flood occurs or that lets people recognize dangerous situations. In the Netherlands, many problems are signaled by civilians and reported to the Water Boards. If civilians are more aware of dangerous situations, it is more likely that they are able to report any problems. As for relief, in the healthcare it has been shown that children react better to treatment while they are exposed to a game that deals with their illnesses than children who are not (HopeLab, 2006). It could turn out that exposing flood victims to a game about their situation could help them cope with it. However, it seems that for flood defence informing and awareness creation through games is more valuable and suitable than disaster relief.

In sum, games can have an “educational value” for flood defence. This educational value is not limited to transferring knowledge and skills, but includes testing measures (and evaluating them), practicing rare and unexpected situations, informing civilians, and creating awareness.

3.2 The organizational value

Another value for using serious gaming consists of a number of external effects. These are effects that the development did not initially aim for, but which nevertheless occurred. A first and quite obvious one is that the game becomes a *knowledge repository*, a cultural artifact within the organization. Members come and go, and the new ones could learn the required knowledge and values through the game. In this way, the game preserves and mediates knowledge comparable to how books and reports are used.

Another effect happens before the game is finished. A game demands to be a coherent and consistent system. Otherwise it becomes non-intuitive, illogical and frustrating to play it. To fulfill this requirement existing knowledge has to be made explicit. This extraction is quite difficult as most knowledge implicitly resides inside the minds of experts. Next, inconsistencies have to be resolved. Again, this task is daunting, as experts may disagree or information may be irreconcilable. To get this done, a *shared and explicit vision* among researchers and practitioners has to be created.

Discussions about the content of the game do not stop when the game is finished. They continue as the game may in fact stimulate *discussions*. Playing the game could lead users to think of issues that they did not think of before or look at issues from a different perspective. It makes them aware of differences and other possibilities. This is a third possible effect; the game could become a vehicle to discuss issues.

The above-mentioned external effects, becoming a knowledge repository, providing a shared and explicit vision, and stimulating discussions can together be referred to as the “organizational value” of a game. The use of serious gaming goes beyond the transformation of a number of individuals. It has a significant impact on the overall organization (or even the community at large).

4. THE LEVEE PATROLLER CASE

Many games about flooding already exist. However, these types of games are mostly pure entertainment. Take for example a game called *Flood*. In *Flood* the player controls Quiffy, a strange amphibious creature, on his quest to stop the flooding of his underground world. This quest involves avoiding obstacles and defeating enemies with dynamite and grenades. Nonetheless, some serious game

applications about flooding exist, like *Levee Patroller*. This game was initiated and developed by Deltares to train “levee patrollers” the appropriate inspection skills. These are people, volunteers or employees of a Water Board, that inspect the levees regularly or in case of emergencies. This Section illustrates how this serious game is applied for flood defence. Section 4.1 delves into the motive and overall concept of this game, while Section 4.2 concentrates on the development and content of the game.

4.1 The motive and overall concept

The Netherlands is a unique country in that more than half of it lies below sea level. To protect the land it has thousands and thousands of kilometers of levees, 3.585 primary and 14.000 secondary levees to be precise. Although new techniques are being developed, such as laser and satellite scans, to observe the status of these infrastructures, levee patrollers will probably remain an important chain in mitigating and responding to failures. Within the crisis organization of the Dutch Water Boards these professionals are referred to as the “eyes and ears”. They are the first to observe possible problems and upon their observations further action will be taken.

A patroller’s job requires the ability to recognize failure symptoms on time and properly communicate relevant findings. Patrollers indicated that they have learned these required skills from more experienced patrollers. However, failures are quite rare and reports about failures in the past are difficult to locate. This means that many patrollers have never experienced a failure. Since material about failures in the past is hardly present, it makes it even harder to know what to look for and how to deal with it. On top of this, Water Boards indicated that on average patrollers are active for 5 years. This is a relatively short time period, especially for exchanging knowledge.

Some of the Water Boards recognized this problem and looked for a way in which it was possible to let their patrollers experience and practice with failures in a safe environment. The game *Levee Patroller* was the result of this. Not surprisingly, in this game the player plays the role of a levee patroller. The basic purpose of the game is to find every failure and report it. This finding and reporting occurs in a three dimensional world that has been built with the *Unreal Engine*, the technology behind successful games like *Unreal Tournament*. During a scenario, the player has to return to failures to see if they worsened or stabilized. If a failure becomes worse, the player may need to take an appropriate remedial measure.

The game ends whenever all failures are found and reported as stable. The game can also end when a player cannot find a critical failure. In this case it will lead to a levee breach that will flood the whole region. At the end of a scenario a score is given from 0 to 100%, which is based on several criteria, such as the number of correctly reported failures and the accuracy of the diagnoses. A score of 55% is considered sufficient, but only if none of the levees are breached.

The game is currently licensed to 6 Water Boards. These Water Boards have set up specific game rooms to play the game. Other Water Boards are still considering a license or decided to hire us for setting up a workshop of which the game makes an important part of. The overall results of using the game are satisfactory. Patrollers indicated that they find it realistic, engaging, and educational. For many patrollers it is difficult to stop playing and some of them even asked if it was possible to take the game home.

4.2 The development and content

In developing the game we had to cope with the large variety that comprises the worlds of the Water Boards. The regions of the specific Water Boards differ; some have solely primary levees, some solely secondary, and others have a mix. In addition to this, the soil composition of the levees in these regions, the amount of responsibility given to patrollers, the procedures in inspection, the organizational structure, and the terminology differ. We partly handled this diversity by creating a non-existing region that highly resembles the Dutch polders, but which also unites many of the unique characteristics of the several regions. Furthermore, failures were included that could have an occurrence in each of the regions. Finally, a scenario generator was created that gives the user the possibility to select a specific region

(e.g., a region with foremost primary or secondary levees or both), the type of responsibilities, the type of failures, and the weather.

As no uniform terminology as well as categorization existed, we decided to make our own based on information from experts and interviews with a number of Water Boards. In the end, we reasoned that a failure consist of one or more signals and is caused by a typical “failure mechanism”. A failure mechanism is defined as a specific underlying pattern of how a levee fails. We recognized five patterns: sand boils, macro(in)stability, micro(in)stability, erosion inner and outer slope. The following sorts of signals that could make up a failure have been defined for the game: Rip-rap/pitching stone, grass revetment damage, crack, settlement, horizontal movement, uprise, liquefaction, water outflow, overtopping/ overwash, floating waste, human activity, and biological activity. Players have to indicate for each failure what signals occurred, report their specific characteristics (e.g., length, width etc.), and have to make a diagnosis of the failure mechanism based on this information.

Figure 2: Micro(in)stability (left) and Macro(in)stability (right)

The current version of the game has eight dynamic failures, which have been designed in close collaboration with experts. For instance, the failure that is caused by macro(in)stability first starts off with a number of horizontal cracks on the top of the levee. At a later moment, the cracks become larger, vertical cracks start to emerge as well as a settlement and a horizontal movement. At an even later moment, the settlement is complete and another horizontal movement can be observed. The idea of the game is that players keep track of this development. In this way, they acquire a mental model of how such a failure looks like and develops over time. By playing several scenarios with different failures users become in addition more mindful. They learn how to differentiate among failures and to test their assumptions. By incorporating even more failures and regions in the next versions of the game we hope to further promote this development.

5. CONCLUSION

Floods do not occur that often and when they do, they happen unexpectedly. This characteristic makes it difficult to be prepared for these types of disasters. Situations cannot be trained and measures can hardly be tested. To fulfill this educational gap, serious games, games that are fun, meaningful and valid, can become an important approach to flood defence. These games provide compelling, authentic, and safe environments and give its users experience. They differ from other frequently used tools, like DSSs and simulations, in the role of its users and the outcomes.

Using serious games for flood defence has two values, an educational and organizational value. The educational value consists of the acquisition of elaborate mental models and increased awareness. This makes it possible for professionals and civilians to be more mindful when encountering crisis situations. This is a state in which a person is open to new information, continuously refines and differentiates

expectations, and has an implicit awareness of more than one perspective. In addition to this educational value, serious games can have an organizational value. These games could become a knowledge repository, provide a shared and explicit vision, and stimulate discussion.

Although further research is needed, *Levee Patroller* is a good example of how a serious game could be applied for flood defence. So far, the results of this game are convincingly positive. This supports the idea that a playful approach can be beneficial to flood defence.

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