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Societal impact of a Serious Game on raising public awareness: the case of FloodSim

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ABSTRACT

This paper presents an evaluation of the societal impact of a simulation-based Serious Game. FloodSim was developed with the aim of raising awareness of issues surrounding flooding policy and citizen engagement in the UK. The game was played by a large number of users (N=25,701) in a period of 4 weeks. Quantitative and qualitative analyses (on a reduced data set) were carried out in order to explore the impact of FloodSim play in raising the general public awareness around flooding in the UK. The results suggest FloodSim was hugely successful in generating general public interest and there was evidence that (a) FloodSim increased awareness at a basic level and (b) that despite the simplicity of the simulation, players perceived FloodSim to be an accurate source of information about flood risk and prevention. This suggests that serious games such as FloodSim have potential to engage the public and raise awareness of societal issues. However, FloodSim only raised awareness at a basic level. It is suggested that more needs to be done to endow serious games with pedagogical principles and more care should be given to the accuracy of the information they convey. The appropriateness of games as an educational medium for raising awareness of complex, real-life issues should also be carefully considered. This study throws some light on the potential of simulation-based Serious Games to offer experiential learning, engage users with serious topics while raising public awareness and understanding of social issues such as flooding and related policymaking. Future research is outlined consisting of identifying the problems and challenges in designing and developing serious games while considering pedagogical principles.

Keywords: Serious Games, Societal Impact

1. INTRODUCTION

This paper throws some light onto the issue of raising awareness through a serious game. The goal of this research project was to explore the effectiveness of serious games, particularly their impact in raising awareness of the issue of flooding among the general public in the UK. To achieve this goal, a working definition of awareness related to flooding issues is proposed and, by analyzing users' feedback and responses to an interview, the societal impacts of game use are presented. The results of this research are an important contribution to the serious games research and development communities since on the one hand they indicate the danger of: 1) over-simplifying complex social problems in a game format, and: 2) not considering pedagogical and user-centered design methodologies for the design and development of serious games. On the other hand, by analyzing the responses, and talking to users, it was clear the game generated high levels of engagement not only in the UK where it is based but also overseas. The game also served as a platform to define and study the theoretical concepts of awareness, what it means and how to measure it to assess societal impact of games. Given the large number of users (N=25,701) all over the world, FloodSim is largely a success story as it attracted users from every stratum of society. Although a large data set was collected, the interest was to analyze the game's impact in UK based players. This data subset allowed analyses of the player's location, gender and age. The results suggest serious games should be designed and developed considering pedagogical aspects that do not get in the way of the motivating elements of a game. However, this paper suggests that serious games designers and developers should consider pedagogical principles to inform the design of their games so that learning or awareness-raising, leading to behavioural change for example, can be integrated into the game. A closer collaboration between researchers and developers from early stages of design might help alleviate the problem of raising awareness at a very basic level.

2. SERIOUS GAMES FOR LEARNING

The term serious game is used for game-based situations used for non-leisure purposes or serious applications such as learning and training. The use of serious games for learning or training is a trend which has increased lately due to the relative availability and ease of use of the Internet and increasing broadband connectivity. Serious games not only open up the possibility of

defining learning game-based scenarios but also of enabling collaboration among players that might lead to better learning outcomes (Tudge 1992). A perceived benefit of serious games is that they enable learners to engage with learning situations in an engaging, multimodal, narrative oriented fashion which may enable learners to fully immerse themselves in a learning situation (Csikszentmihalyi 1990) possibly leading to learning gains (Craig, Graesser et al. 2004). The multimodal nature of serious games (de Freitas 2008) and the facilities they offer to share resources, spaces and ideas greatly support the development and employment of serious games for learning and training. The use of games (serious or leisure oriented) as learning devices is not new. The popularity of video games among younger people, led to the idea of using them with educational purposes (Malone and Lepper 1987). As a result there has been a tendency to develop increasingly complex serious games which are developed considering both pedagogical and playful elements. A common use of this approach is the use of intelligent agents (Lester, Towns et al. 2000) to provide pedagogical support (Lester, Converse et al. 1997) while providing a motivating environment for the learner (Yoon, Blumberg et al. 2000). However, agents per se are rare in serious games which often include metaphors (Laurel 1997) and narratives (Iuppa, Weltman et al. 2004) to support learning and training in game-like scenarios. Examples of this trend include the support for the development of cultural and linguistic abilities (Johnson, Wang et al. 2007), the use of games to recruit people, i.e. America's Army cited in (de Freitas 2008) or the use of Second Life to support the training of paramedics in Stanford Medical School, also cited in (de Freitas 2008).Some serious games have included the use of concepts borrowed from the Artificial Intelligence in Education (AIED) community, particularly for modelling the learner in order to provide appropriate feedback. For example, efforts are being taken to use games as a test bed, in combination with sensors, to test the sensors' feasibility to inform the models of the students. The use of eye-tracking (Conati and Merten 2007), multimodal elements (Kapoor and Picard 2005) sensors measuring the person's positions during the interaction (D'Mello, Craig et al. 2005) and brain computer interfaces (Rebolledo-Mendez, de Freitas et al. 2008) are examples of this trend. A trend that contributes to what can be considered as 'perceptual modelling' whereby task, function, social and cognitive measures need to be brought together to create accurate modeling. It is only recently that serious games have been developed to develop awareness of social problems such as the impact of flooding. In previous research conducted by researchers at the Serious Games Institute a link between has been found between game-based learning and behavioral change (de Freitas, 2009). This is being developed in ongoing research around training purposes for game-based approaches. The importance of behavioral change to awareness raising is unclear, however implications indicate that in order to change behavior a similar set of perceptions need to be invoked through the game design (e.g. motivation, engagement, user's perception of the problem or challenge and user's perspective or identity). Role play is a powerful tool for behavioral change, and as such it is hypothesized that awareness raising would also employ the same or similar elements. This is a wider aim of research into the efficacy of serious games that has led the

employment of methods for evaluation of games such as those outlined in this paper.

3. FLOODSIM

FloodSim is a simulation developed by PlayGen Ltd[1] and commissioned by Norwich Union[2]. The objectives of the simulation are: to 'help raise awareness of the flooding issue surrounding flood policy and Government expenditure and to increase citizen engagement through an accessible simulation'. FloodSim allows the player to take on the role of flood policy strategist employed to implement a selection of strategies for addressing the risk of flooding over the course of 3 years based on a pre-defined budget, see Figure 1. A brief comment on the advantages and drawbacks of each option is presented when the mouse is rolled over each icon. The player selects each strategy by dragging the icon over a region of the UK.

Figure 1 FloodSim's interface

Players need to deal with various elements of flood related problems and policy in a period of three years. In year 1 the player chooses what type of barriers to build, which regions to concentrate on, and how many funds to allocate to maintenance. In year 2 the player considers building planning, education, warning systems and grants. In year 3 the player makes decisions regarding drainage systems and emergency services. The effects of the player's choices, given random weather conditions are presented at the end of each year (Figure 2).

FloodSim was aimed at the general public and was not intended to be a realistic and detailed simulation of the causes of flooding and the process of implementing flood protection policies. The simulation is relatively short, simple and easy to play, e.g. players use drag and drop commands and click buttons to continue. The effects of strategy choices in each year does have effects in subsequent years, as each UK regions in the game has attributes that can be affected with the players choices: Current

Level of Protection, Current Population, Flood Risk. If strategies are not well considered the consequences could be flooding of cities, such as London (Figures 3 and 4) or Liverpool (Figure 5).

Figure 2 Feedback provided by FloodSim

Figure 3 A simulation of floods in London's Westminster

At the end of the simulation, players are asked their demographic information (location, age range, and gender) and are invited to answer a few questions regarding their experience with FloodSim, and may leave general comments which require an email address. The feedback section was organized in 5 areas for the player to comment on relating to issues to Flood Policy. FloodSim was released in 2008 following the devastating floods that were experienced in the UK in 2007. It was advertised through various websites and magazines, and could be accessed freely from PlayGen's website.

To throw some light onto FloodSim's societal impact in raising awareness about flood policies and citizen engagement, the data collected during the first 4 weeks was analyzed. These analyses were undertaken during November 2008. The purpose of these analyses was to assess the extent FloodSim raised awareness of the risk of flooding and what players thought could be done in terms of flood prevention.

Figure 4 A simulation of floods in London's Olympic site

Figure 5 A simulation of floods in Liverpool

4. Methodology

The evaluation was based on three sources of data: a) the demographic information left on the site, b) the feedback left on the site, and c) telephone semi-structured interviews.

4.1.1 Demographic information

Although FloodSim was played by participants from all over the world, the analyses outlined in this paper focused on UK residents only. There were 25,701 players between 8th August and 8th September 2008, 82.78% male and 17.22% females all UK residents. The players were of all ages, see Figure 6, but the majority of players were aged between 21 and 30 years-old (38.27%) followed by players aged between 41and 45 years-old (25.70%). This population was geographically located across the UK territory as follows: East (17.95%), East Midlands (5.44%), London (13.58%), North East (7.95%), Northern Scotland (4.28%), North West (13.48%), Northern Ireland (1.26%), South East (10.72%), Southern Scotland (4.74%), South West (12.63%), Wales (1.92%) and West Midlands (6.05%). Higher numbers of players came from the worst affected areas during the

2007 flooding in the UK: North West, East, and South East; however, a correlation could not be made.
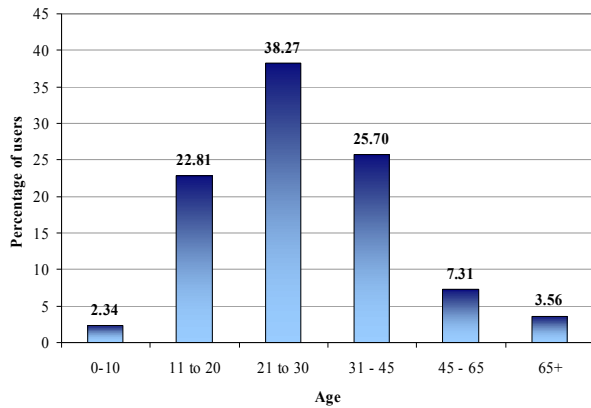

Figure 6 Breakdown of UK residents by age

To throw more light onto how much the serious game raised players' awareness, only the players who provided a contact email addressed were considered as potential interviewees (N= 281). The feedback left at the end of the interaction was also analyzed but only for this subset of the population. It was made this way since follow-up interviews were planned to address trends observed in the analyses of the feedback provided by the players who left a contact email address. The rest of the data was not considered for analysis as the players could not be contacted.

4.1.2 Feedback

The feedback provided by players at the end of the game was analyzed using the NVivo qualitative data analysis software. This allowed identification of themes in which the feedback could be categorized (each piece of feedback was only placed in one theme). Table 1 presents a summary of the themes. Please note that the number of instances is not relative to a fixed number but represents the total number of these words found in the feedback.

Instances	Theme
121	Short (2-word) positive comment
77	FloodSim was informative
24	Opinion on cause of/solution to flooding (no mention of FloodSim)
17	Nonsensical or irrelevant comment
14	FloodSim lacks detail
9	Simulations are a good way of raising awareness
8	FloodSim is difficult to play
3	Educating people about flooding is important
3	Questioned the accuracy of FloodSim
2	FloodSim is biased
2	FloodSim was OK (neither positive nor negative)
1	FloodSim is dull

Table 1 Categorization of feedback into themes

The majority of feedback fell into two categories: 1) positive comments (77 instances) such as 'good game', which did not provide enough detail to indicate what was meant, e.g. was the simulation an enjoyable experience or was it a good educational tool, and 2) Comments (121 instances) that suggested the player thought the game was informative, such as 'a good game and it has helped me to understand flooding and how the government has to deal with it'. The feedback either stated that the player thought the simulation increased their own understanding of the issue of flooding or was a statement about the value of the simulation in raising others' awareness.

The feedback in the second category indicated that players thought the simulation to be an accurate portrayal of the risk of flooding and the available strategies for flood prevention. Many comments were quite short and simply stated that the game was 'a good educational game' or that it was 'thought provoking'. Other players stated that the game increased their understanding in the following sense: (a) that addressing the issue of flooding is a complex issue that has no absolute solution, (b) that there are financial constraints on what can be done to combat flooding, and (c) their understanding of the range of available strategies. For example, one player wrote: 'excellent piece of information and really informs you about flood protections and how they work'. This is in contrast to a few players who questioned the simplicity of the simulation (14 instances), suggested it was biased (2 instances), or questioned the basis on which the results of the chosen strategies are inferred (3 instances). For example, one player wrote: 'fun but not really instructive, could mention real mitigations such as Suds, retention ponds etc. Over 5/6 years would be more viable. What about flooding from sea?'

The feedback was generally quite short (max 50 words) so it was not possible to draw any detailed conclusions about the players' understanding of flood risk and prevention and how FloodSim might have changed that understanding. However, given the simplicity of the simulation (see section 3), it is interesting to note that many players appeared to consider it an accurate source of information. This indicates that simulations such as FloodSim have the potential to engage people and raise awareness of societal issues. It also suggests that in developing serious games and simulations it is important that the information presented is accurate. These issues are further explored in the discussion.

4.1.3 Interviews

The interviews were conducted during November 2008. An email invitation for a 10-minute telephone interview was sent to 281 players who left feedback (and their email address) after playing FloodSim. The purpose of these interviews was to gather more information that could give an insight, based on players experience with FloodSim, into player's knowledge of flooding and whether they felt the game increased their understanding of the issue. As the majority of email addresses were not valid and eleven responses did not lead to interviews (either as respondents were underage and parental consent could not be obtained or they did not follow up) only 14 replies led to successful interviews. All interviews were anonymous. The interview question included:

1. How concerned are you about the risk of flooding?

2. Do you feel you understand what the risk of flooding in your area is? Follow-up: where do you get information from? (i.e. Environment Agency)

3. Do you feel you understand what can be done to address the problem?

4. Are you aware of what measures you can take for your home (if in flood risk area)?

5. From where would you say you have collected information?

6. Did FloodSim contribute to your understanding? How? Follow-up: your understanding of the risk of flooding, what can be done to prevent flooding, the complexity of the problem, etc

7. What did you think of FloodSim?
      a. What did you think was its purpose?
      b. Did you think it achieved this purpose?

8. Is there anything else you would like to add?

The nature of the questions was agreed beforehand and the interviewees' anonymity has been preserved at all times. The interviews for all the participants were transcribed fully and analyzed to build a picture of each interviewee's understanding of the issue of flooding and their perception of FloodSim.

4.1.3.1 Interviewees

The interviewees' age ranged from 25 to 59 (8 out of the 14 were aged between 32 and 37). Of the 14 interviewees 4 had a detailed understanding of the issue of flooding either from their profession, e.g. engineering or architecture, or from involvement in local flood prevention groups.

4.1.3.2 Interview structure

The interviews were semi-structured. The prepared questions included the interviewees' age and occupation, their concern on the flooding issue, their knowledge of it (including preventative measures), whether there is a particular source of information they consult, why they accessed the FloodSim site, their perception of the purpose of FloodSim, their evaluation of FloodSim (in particular in raising awareness), what other issues they would consider appropriate to the development of a simulation, and whether they considered digital engagement in general an appropriate means for engaging the public in policymaking.

4.1.3.3 Interview procedure

The email invitation detailed the purpose of the interview and explained that the interviews would be recorded for the purpose of transcribing. This information was provided at the beginning of the interview and the interviewee was asked for their consent to have the interview recorded. The interview structure varied depending on how knowledgeable the interviewee was about flooding.

4.1.3.4 Interview results

A distinction could be made between the 4 interviewees who had a detailed knowledge of the problem of flooding, and the 10 interviewees who had some knowledge, but quite a general understanding. For example, one interviewee was a civil engineer who had worked on river and marine works and another had worked with the local council in flood protection for over 10 years. In contrast, those with a general understanding had some knowledge of the risk of flooding, but not a detailed understanding that comes from being involved in trying to

address the problem directly. There was evidence, from the 10 interviewees with a general understanding of flooding, that the FloodSim simulation raised awareness of the issue of flooding at a basic level. Specifically, the interviewees identified the following issues that the simulation conveyed: that predicting and preventing floods is a complex problem that does not have a solution, that flood prevention is a matter of prioritizing what needs to be done given financial constraints, what measures are available for flood prevention and the advantages and disadvantages of each, and the unpredictability of the weather. For example,

> Interviewer: so what kind of information did you get from Floodsim?
>
> FloodSim player: um, the fact that there's an awful lot of areas where it's - you wouldn't think are protected areas but they definitely need more awareness of it - it definitely needs to be looked at in a more extreme way - a lot more money spent on it than the government currently is, that's for sure - I mean the monetary values on the FloodSim program itself although they seem to be vast amounts when you start you suddenly realize that you haven't actually got that money to do everything at once. It seems to come through very quickly on that program

Eight interviewees said that the simulation raised their own awareness on one or more of the above issues, while two (who were teachers) said it raised their students' awareness (they had used the simulation in the classroom). For example, one interviewee commented:

> FloodSim player: yeah, yeah, I've made sure I've used it in school - in lessons and as a homework - but in terms for me as a geographer I think it absolutely gets to the crux of it you know, the difficulty of managing flood prevention, flood risk and understanding that the weather is unpredictable
>
> Interviewer: and so would you say that it's helped increase their understanding of the flood issue
>
> FloodSim player: it definitely has and more to the point understand the difficulty in managing a flood situation, a flood risk, flood management, yeah

However, as discussed by the 4 interviewees who had a detailed understanding of the flooding issue, the simulation was a basic representation of a very complex issue. The question that arises is to what level did the simulation raise awareness. FloodSim does not (and was not intended to) give detailed information on the issue of flooding. Many other issues such as political issues surrounding planning permission and how it is regulated, how much funding is allocated to flood prevention, the criteria to which protective barriers have been built, the changing weather conditions, the maintenance of the sewers, and the effects of deforestation, are not considered. The analysis of the issue of flooding given by these 4 interviewees was much deeper than the rest. For example,

> FloodSim player: a bit basic - yes a little bit too simplistic. Flooding issues are a very complicated infrastructure concerned problem and we don't know for certain what global warming is going to do to us - most of the experts would agree there'll be some form of sea level of rise between 1 to 5

metres over the next hundred years. We don't know for sure because one thing that's not a straight line of cause and effect. So my view is you prepare for the worst and hope for the best but we are going to have to do a lot of work at local level, at district and particularly at county level to protect our populations. The game didn't really - it's ok but at the end of the day it's a lot more complicated.

Or as phrased by another interviewee, FloodSim 'did not open up the whole issue'.

The fact that many interviewees appear to have found FloodSim a valuable source of information is positive. FloodSim appears to have raised awareness at a basic level: that preventing flooding is a complex problem that has no straightforward solution. However, for a significant impact to be made that will engage the public in policymaking and/or encourage them to become involved in flood prevention it is important that they understand the issue in more depth.

Raising awareness is very difficult issue. As one interviewee said:

> FloodSim player: I've run community groups for quite some time and I can tell you that I've tackled this problem head on over the last ten years and it's very difficult, because people polarise problems, they simplify the problems, and some problems are just not simple. So it's a slow process of education and re-drawing the parameters, re-mapping if you like your expectations […]

Another interviewee also discussed the difficulty of raising awareness

> FloodSim player: um, how do you raise awareness... that's a difficult one. Um I think we need to use um the recent devastating effects say Norfolk, Hull, Tewksbury, Gloucester, right as examples and have good scientific documentaries to analyze what's going wrong and what can happen - you almost like you need good documentaries put to the mass of people. The ones that have been done on the BBC and I think Channel 4 did one as well, they've tended to be sensationalized, some of the things - I mean the one I remember was that they did a computer simulation and if a dam broke in Birmingham it would cover a whole area. But I mean that - I mean that's not an issue - I think it was just sensationalizing the subject. I'm - the problem is the public do not like detail, ok, and you have to go into detail to look at the flood situation anywhere and people's eyes tend to glaze over when you start talking about detail […]

It is beyond the scope of this paper to analyze the issue of flooding and how awareness can be raised. Although, as has been outlined in previous research (e.g. de Freitas & Jarvis, 2009), the success of the game-based approaches seems to lie in the increased participant motivation levels (role play elements of the game), engagement of the participant in the active learning (simulating the real thing), participant's perception of the problem or challenge (outlined in the policy dimension of the game) and user's perspective or identity (role play taking on the identity of the policy maker). Evidenced by the fact that the majority of those interviewed did engage with the core basic level of awareness raising:

that flooding is complex with different solutions and with financial restraints, indicating that the game has been successful in awareness raising on this level at least. With the more knowledgeable interviewees, it offered an opportunity for reflection upon how awareness could be raised using multimodal approaches.

The results, moreover, suggest that in developing serious games a more careful consideration about what it is meant by raising awareness (basic, intermediate or advanced levels of awareness linking to how complex the information portrayed is for the player) and, consequently, in what sense the game will have a societal impact; that is, will the game lead to a consideration of the issues or lead to direct behavioural change. Similar to the feedback (section 4.2.1), the interviews indicate that the majority of interviewees were positive about FloodSim. This suggests that simulations such as FloodSim have the potential to engage the public and raise awareness. However, the interviews also indicate that awareness was only raised at a basic level. FloodSim did not increase players' understanding to a level that would enable them to engage in policymaking in their area or understand debates about flood prevention strategies across the country. For this a longer game would need to be developed, the game may need to be supplemented with face-to-face learning sessions, or other modes of learning.

5. DISCUSSION

It is interesting to point out the fact that untypical age groups such as 45+ players account for 10.87% (approx. 2790 players) of the total population. Also, teenagers who would not normally play Serious Games account for 22.81% (approx. 5860 players) of the population. These percentages provide an indication of the potential offered by Serious Games to reach out people from all strata of society. The majority of feedback suggested that players were positive about FloodSim. Many explicitly stated that they found the simulation educational. It is not possible to be definite about how representative these comments are across the entire population who played with the simulation. However, it is unlikely that only those who had positive things to say would choose to leave feedback, particularly as the proportion of positive and negative feedback has generally been even in other games and simulations developed by PlayGen. The novice players who were interviewed (*novice* in their understanding of the issue of flooding) tended to agree that playing FloodSim provided them with reliable information and that they enjoyed and learnt from having played the game. This data suggests that games such as FloodSim have the potential to engage the public and, therefore, be valuable educational resources.

However, the awareness of the novice players who were interviewed was rather superficial. This was apparent in their discussion of the issue of flooding. Knowledgeable players seemed to agree that flooding is a complex issue involving many more factors than those presented in FloodSim. Issues such as scientific evidence for the causes of flooding and the over exposure and simplification of the topic by the media seem to be common denominators. It is evident that awareness of flooding issues is more complex than simply presenting some basic information in a simulation-based Serious Game. FloodSim's

website states: 'FloodSim is a serious game with the aims to raise awareness of the vast number of issues surrounding flood policy and Government expenditure and to increase citizen engagement through an accessible simulation'. Considering the evidence collected, it is clear the majority of players interviewed achieved only a superficial level of awareness, which would not be sufficient to allow them to engage with or understand debate on flood policy and Government expenditure. This is an interesting finding as it suggests the game operates, or has the capacity to, at two levels: 1) serving as an engaging medium for the majority of users who enjoy video games for learning a new topic, and: 2) serving a learning resource where players with different backgrounds and levels of knowledge of the topic find relevant information. The present evaluation shows that in developing serious games and simulations it is essential for the pedagogical aspect of the design to be on an equal level with the element of engagement. It also shows that it is well worth the effort of exploring the development of serious games for raising awareness on societal issues, as they have the potential to reach wide numbers of the public. Given the large numbers of players that FloodSim attracted it is worth considering the development of a revised version of this game. The present evaluation may be valuable in this process.

Part of this exploration will involve determining to what extent games are a good medium that lends itself to detailed portrayal of an issue at deeper levels of engagement. An essential aspect of the game alongside its feedback to the user, was comparing their choices with other players choices. This dimension of the game could be used to explore comparative decision-making strategies, allowing the player to make errors and correct them, to compare their decisions directly with others and to play collaboratively making collaborative and maybe localized decisions. This strategy could provide a model for game-based decision-making where teams of players based in an area could respond to different scenarios on the fly. This approach could allow for more complex decision-making strategies and allow for a more persistent game play. This approach would allow for more diverse responses to different situations reflecting how real world issues tend to have no definitive solution and often there exist directly opposing interpretations of scientific data, and yet difficult decisions need to be made. In the case of a more detailed implementation of FloodSim, developers may have to make decisions about the effect of the players' choices. How would they realistically decide the effectiveness of the different strategies? Similarly, in a simulation about energy generation: developers would have to make decisions about the relative advantages and disadvantages of, for example, nuclear versus wind energy? Given the current debate on such issues it would be difficult to do so, and in some cases the design would involve taking a political stance.

It is acknowledged that the qualitative analyses were based on a small sample and, therefore, the results should be considered as indicative of and not as a representation of the larger population of 25,000 users, yet when supplemented with the email responses the game does seem to have raised awareness to the basic level of problem identification and understanding the complexities around solutions finding. The intention of this paper is to raise important questions that need to be considered in the evaluation of the impact of Serious Games in raising

public awareness. While some evidence has been presented regarding the efficacy of game-based approaches for behavioral change (de Freitas 2009) the links with awareness raising is only beginning to be studied as a distinctive area of serious games studies. Another issue that arose from the study of the feedback consists of studying the background of the players and their willingness to further engage with FloodSim. Of the 281 emails sent, only a small percentage (8.9%) was happy to participate in the interview but almost half of them were not considered as they were underage or did not answer the telephone. This fact is revealing and suggests that a very small percentage of the original 25,000 considered the game serious enough to leave verifiable information about them. While large study samples are needed to fully explore the efficacy of serious games, other techniques for data collection may be needed, such as log analysis for example. While the studies about serious games are underway, methodologies that integrate usability, demographic and observational techniques of data collection may be the most appropriate. This as other studies however does point to the power of the form for engaging and motivating users, but more rigorous methods of design and development of serious games are clearly needed if the form is to mature fully and meet the users requirements.

6. CONCLUSIONS AND FUTURE WORK

The impact of a serious game on flooding in raising the general public's awareness about flooding in the UK was studied. Data on players aged 21-45 years-old from 25,701 players was analyzed. Qualitative analyzes were carried out based on those players who left written feedback (281 players) and interviews from 14 players. The results suggest that: (a) the majority of players were positive about FloodSim, (b) those players who did not have a deep understanding of the issue of flooding found FloodSim educational, and (c) FloodSim raised awareness of flooding at a basic level: that flooding is a complex issue that has no straightforward solution. These results suggest that Serious Games have the potential to engage a large number of users. Simulation-based learning seems to engage large sectors of the population. It has been found that this medium has potential to increase awareness of important societal issues amongst sections of the population that would otherwise not be motivated to explore them. There were players of all ages although the majority was male players between 21 and 45 years of age.

The present evaluation indicates, however, that FloodSim did not increase the players' understanding substantially and that measuring awareness of flood issues proved to be a particularly difficult endeavor. In the literature, there are examples where the use of serious games has been shown to be effective (Dieleman and Huisingh 2006; de Freitas and Neumann 2008). However, the goal of increasing the public's awareness of societal issues is an ambitious one and would require a more thoughtful design process with a stronger pedagogical underpinning. An approach would be that Serious Games incorporate stronger pedagogical components aimed at generate or increase awareness that will support players in developing an informed opinion on societal issues. By including pedagogical strategies such as guiding the player through structured game-based learning activities or providing timing help, it would be easier to evaluate the learning

and the degree of awareness achieved by individual players. The use of pedagogies in computer-based education has yielded positive results in learning gains (Luckin 1998; Papert 1983). It is possible that Serious Games can achieve the goal of raising public awareness. However, a clearer analysis of what this means and how it can be achieved is needed. Moreover, better measures to define whether the type of motivation that engages people with games is conducive to achieving deeper levels of understanding are also needed. Is this a matter of modeling their perceptions more accurately and feeding back into game design, or can game design find ways to present more complex models that can be engaged with more deeply by players? It is hypothesized that elements of both are needed.

For future endeavors to be more effective, it is suggested that there needs to be closer collaboration between developers and academic partners so that Serious Games can be endowed with strategies, feedback and pedagogies and the potential of commercially available Serious Games to attract large number of players might be exploited fully. Following on from the interviews, PlayGen and Norwich Union (an Aviva company) – who sponsored the game – talked to a number of MPs who have an interest in the flooding issue. During a meeting in the Houses of Parliament, the feedback reported in this paper, people's thoughts and perspectives on both the FloodSim game and general flooding issues were presented to MPs. One of the purposes of developing FloodSim was to provide policymakers with a unique opportunity to engage with citizens opinions on the problem. Though much work is still to be done, FloodSim can help encourage debate on the issue of flooding in the UK. Furthermore, based on the results, it is believed that the serious game has the potential to offer new approaches to collaborative decision-making which could support novel methods for both increasing public engagement into politics and in time lead to more democratic methods of policy making where localized and national groups can input views directly that can be taken into consideration as part of the wider policy development around particular issues such as flooding and energy management. A larger-scale evaluation also needs to be defined around improved versions of FloodSim.

REFERENCES

Conati, C. and C. Merten (2007). "Eye-Tracking for User Modeling in Exploratory Learning Environments: an Empirical Evaluation." Knowledge Based Systems **20**(6): 557 - 574

Craig, S., A. Graesser, et al. (2004). "Affect and learning: An exploratory look into the role of affect in learning." Journal of Educational Media **29**: 241-250.

Csikszentmihalyi, M. (1990). Flow: The Psychology of Optimal Experience. New York, Harper and Row.

D'Mello, S., S. Craig, et al. (2005). Integrating affect sensors in an intelligent tutoring system. "Affective Interactions: The Computer in the Affective Loop Workshop" In conjunction with the International conference on Intelligent User Interfaces. p. 7-13.

de Freitas, S. (2008). Serious Virtual Worlds: a scoping study. JISC. London, Serious Games Institute, Coventry University.

Dieleman, H. and D. Huisingh (2006). "Games by which to learn and teach about sustainable development: exploring the relevance of games and experiential learning for sustainability." Journal of Cleaner Production **14**: 837-847.

Freitas, S. d. and T. Neumann (2008). "The use of 'exploratory learning' for supporting immersive learning in virtual environments " Computers and Education **52**(2): 343-352.

Iuppa, N., G. Weltman, et al. (2004). Bringing Hollywood Storytelling Techniques to Branching Storylines for Training Applications. 3rd Narrative and Interactive Learning Environments, Edinburgh, Scotland. p. 1-8.

Johnson, W. L., N. Wang, et al. (2007). Experience with Serious Games for Learning Foreign Languages and Cultures. SimTecT Conference, Australia. p.

Kapoor, A. and R. W. Picard (2005). Multimodal affect recognition in learning environments. Proceedings of the 13th annual ACM international conference on Multimedia. Hilton, Singapore, ACM.

Laurel, B. (1997). Interface Agents: Metaphors with Characters. Software Agents. J. M. Bradshaw. London, AAAI Press / The MIT Press**:** 67 - 78.

Lester, J. C., S. A. Converse, et al. (1997). Animated pedagogical agents and problem-solving effectiveness: A large-scale empirical evaluation. 8th International Conference on Artificial Intelligence in Education, Kobe, Japan, IOS Press. p. 23-30.

Lester, J. C., S. G. Towns, et al. (2000). Deictic and Emotive Communication in Animated Pedagogical Agents. Embodied Conversational Agents. J. Cassell, S. Prevost, J. Sullivant and E. Churchill. Boston, MIT Press**:** 123-154.

Luckin, R. (1998). 'Ecolab': Explorations in the Zone of Proximal Development,. School of Cognitive & Computer Sciences. Brighton, UK, University of Sussex.

Malone, T. and M. Lepper (1987). Making learning fun. Aptitude, Learning and Instruction: Conative and Affective Process Analyses. R. Snow and M. Farr, Lawrence Erlbaum**:** 223-253.

Papert, S. (1983). The Children's Machine, Basic Books.

Rebolledo-Mendez, G., S. de Freitas, et al. (2008). A model of motivation for virtual world avatars. Eight International Conference on Intelligent Virtual Agent, IVA 2008, Tokyo, Japan, Springer-Verlag p. 535-536.

Tudge, J. R. H. (1992). "Processes and consequences of peer collaboration: A vygotskian analysis." Child development **63**: 1364 - 1379.

Yoon, S.-Y., B. M. Blumberg, et al. (2000). Motivation Driven Learning for Interactive Synthetic Characters. Fourth International Conference on Autonomous Agents, Barcelona.

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