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DESIGNING EDUCATIONAL EXPERIENCES USING UBIQUITOUS AND PERVASIVE TECHNOLOGY

Abstract. The aim of the study was to explore the design of situated educational and compelling experiences using SoundScape technology – which is a ubiquitous and pervasive technology. The design of these SoundScapes was informed by two theories of what makes an experience compelling. We designed two experiences: one that had a goal and the other that did not. Twenty six children then explored both experiences. After exploration, the children completed a semi-structured questionnaire asking them which experience was the more compelling. The children found that the SoundScape with a goal was more interesting and were more likely to want to have another go than the non-goal version. They also made more positive comments concerning the goal version. Mentioning the presence of a goal as important factor in determining why they liked the game. More negative comments were made concerning the non-goal version and the children mentioned the lack of a goal as negative aspect of the non-goal version. One improvement they suggested for the non-goal version was to add a goal and to include more sensory stimulation. They overwhelmingly preferred the goal version compared to the non-goal version and when asked by far the most popular reason was the presence of a goal. So in sum the goal version was found to more interesting and preferred more by the children than the non-goal version.

1. INTRODUCTION

Hull, Reid & Geelhoed (2003) write that the technologies underlying ubiquitous computing are beginning to move from research laboratories to the real world. They argue that a potentially valuable area of the application of ubiquitous computing will be the delivery of situated digital experiences, which are compelling experiences that are delivered via digital technology and reflect and enhance users physical locations.

Situated digital experiences are

(1) Context sensitive, particularly with respect to location
(2) Digitally mediated
(3) Compelling to users

They can be viewed as a new digital dimension overlaying the physical world. The new dimension will be mediated by a user's personal device and by intelligent signposts distributed through the physical space. The aim of this paper is to explore the potential of this technology to enhance users educational experience.

The project focuses on audio as the principle means of communicating to the user. Audio is preferred for two reasons: (i) it is much easier to maintain an illusion of a seamless continuum between physical and digital worlds than is possible with handheld or eyeglass displays and (ii) it is less intrusive form of interaction for users moving through a physical space. For example, Hsi (2003) reported a study of the use of web content transmitted via a handheld computer to support users' experience of a hands-on science museum. She found that the users' experience changed from a

hands-on interactive experience to a heads down one way transmission of information via the tiny screen of a handheld computer.

The technology developed at Hewlett Packard Laboratories, Bristol comprises:

(1) Palm held PC (iPAC) which is hidden in a sealed waist bag,
(2) A wireless LAN card: 802.11,
(3) Head phones,
(4) Sensoring systems (ultrasound),
(5) Client software written in embedded C++,
(6) Server and server side software including authoring software.

This technology was used to create SoundScapes, which are physical spaces where digital audio files are attached to coordinates in the physical space. The users hear the audio file via a wireless LAN when they enter the designer define area. The use of such devices has been defined and described elsewhere as audio augmented reality (Bederson, 1995); situated documentaries (Hollerer et al., 1999) and augmented reality systems (Rozier et al, 2000). A SoundScape can consist of as many regions as the designers require. Each region is allocated a precise location in terms of a centre or anchor point. Regions can be any shape and any size. To this region various forms of digital content can be attached.

The question this paper addresses is how to design situated digital educational experiences, which are compelling. There are a number of theories of what makes an experience compelling and these theories could be used to inform the design of educational experiences. One theory was developed by Kidd (2002) at Hewlett Packard Laboratories, Bristol. It has three dimensions: challenge / self-expression, drama / sensation and social. Another theory was developed by Malone (1981) and Lepper & Malone (1987). They sought to find out what makes learning fun and how instruction can be designed in a way that captivates and intrigues learners as well as educates them. The authors produced a taxonomy of intrinsic motivations for learning. Initially Malone (1981) had 4 dimensions of intrinsic motivation: challenge, curiosity (sensory and cognitive), control and fantasy. Later he (Malone & Lepper, 1987; Lepper & Malone, 1987) extended his theory with Mark Lepper to include interpersonal motivations and added a further 3 dimensions: cooperation, competition and recognition. Lepper and colleagues have reported a number of studies that have shown that learning is facilitated when students used software designed to be intrinsically motivating (Lepper & Cordova, 1996; Parker & Lepper, 1992).

Many similarities exist between the two theories. They both cover the following aspects: challenge, fantasy, curiosity, co-operation and competition. However, there are also many differences between the two theories. An important difference between them concerns the presence or absence of a ‘goal’. Malone & Lepper (1987; Lepper & Malone, 1987) theory explicitly states that an appropriate goal increases student’s motivation, whereas Kidd’s (2001) theory does not. This difference is also interesting because Malone (1981) found that having a goal was an important factor in making an experience compelling or intrinsically motivating.

Therefore the aim of this study was to explore the use these in the design of situated digital educational experiences - in particular to investigate the effect of having a goal on intrinsic motivation. Two experiences were designed using SoundScape technology. The two SoundScapes differed according to whether they have a goal or not. It was expected that the SoundScape that included a goal would be a more compelling experience than the SoundScape that did not.

2. METHOD

2.1. Design

The experiment was a within subjects design. The independent variable was presence or absence of a goal within the SoundScape. The dependent variable was the children's perceptions of the tasks.

2.2. Fonts

The children (n = 26) were aged between 11 –12 years old from a secondary school in Bath. The pupils were selected by the school and were told that they would be spending a day at Hewlett Packard Laboratories, Bristol.

2.3. Layout of the Opening Chapter Page

As already mentioned in the introduction, we used SoundScapes in this study. They were installed in the atrium of Hewlett-Packard Laboratories, which was overlaid with digital auras. An aura is defined by four properties:

(1) A unique identifier, a channel assignment, and a name
(2) A location and the radius of a circle of applicability around that location,
(3) The URL of the audio object associated with the aura;
(4) whether the audio should be looped on completion (Hull, Reid & Kidd, 2002).

The location of the user in the physical space was determined by the emission of pulses from a RF transmitter and from ultra sonic transmitters strung above the physical space, the wearable computers receive these emissions. Depending which ultrasonic transmitters were in the range of the computer, the computer identified its location to within 15cm. The default behaviour of the aura was to act as a switch, so when a user entered a region of applicability of an aura, their client device (see above) immediately fetched and played the audio specified by that aura's URL. It did this via the 802.11b wireless network installed in the building.

It was possible for the user's device to play all audios associated with overlapping auras simultaneously and it was also possible to set channels up with different behaviours. For example, in a past SoundScape (a digitally enhanced walk in the woods - see Hull & Reid, 2003) the auras in one aura were used to trigger

wolf growls to encourage users back into the main area of the SoundScape. However, if the user had already encountered a certain number of the main auras the growling would not occur. This example illustrates the possibility of encoding special aura behaviour based on user's history (i.e. where they have already been in the SoundScape) into the client device (Hull, Reid & Kidd 2002). Another example of special aura behaviour was the possibility of encoding a switch, which changes one digital map for another. Thus, when a user enters a particular aura the digital map changes. This feature was used to implement different levels in the SoundScapes.

Other physical materials used in the study were: a large quantity of yellow material, an inflatable alien dressed in a fairy costume, a transistor radio, a table, a mock compass (sheets of paper with 'N', 'S', 'E' and 'W' marked on them), green material and a plant.

2.4. Questionnaire

The questionnaire consisted of three sections. The first section contained 7 questions and was designed to assess how compelling the children found the two SoundScapes. They were derived from Malone & Lepper's (1987) model of intrinsic motivation. They asked the children: (i) whether they thought the SoundScapes were interesting; (ii) whether they knew what they were doing; (iii) whether they compared themselves with others; (iv) whether they worked with their friends; (v) whether they liked the fact that others could see what they were doing; (vi) whether they would like another go and (vii) whether they liked the fantasy used in the SoundScapes. The second section consisted of a further three open-ended questions, which asked if there was anything the participant liked or disliked about the SoundScape and how they thought they could be made more compelling. The third and final section asked the children which version the children preferred and why they preferred it.

2.5. Tasks

Two tasks were designed and constructed especially for the experiment. One task had a goal and the other task did not have a goal. Two 15-year-old children acted as participant designers during the design phase, in an attempt to make the theme of the SoundScapes more appropriate for the age group of the children involved in the study.

2.5.1. Goal Version

The aim of the 'goal version' was to get three keys from an island to give to a magic transistor radio in order to save Fifi fairy from imprisonment. At the start, the user received instructions from the transistor radio. The transistor radio told the children to pick up some magic dust from Fifi fairy, by standing in the correct location. She explains that the dust enables them to find invisible stepping stones. They then try to find the first stepping stone. Once they found this stepping stone, they were given a

code that helped them to determine where the next stone was. If they missed a stone and stood in the location of the water aura, they lost their dust and returned to Fifi for some more and tried to cross the water again. If they successfully reached the island they were told that they have a key and to return to the transistor. When they reached the transistor radio with a key they moved up a level. This change in level prompted the changing of the audio map and they were given instructions for the second key. The path got more difficult with each level, the third level was the hardest. The physical materials used in this SoundScape consisted of the yellow material to mark the beach, the suspended inflatable alien dressed as a fairy (Fifi), a transistor radio on a table, a compass marked on the sea area, and green material and a plant to represent the island.

2.5.2. The non-goal version

The non-goal task contained all the features of the goal version apart from the goal. The audio for Fifi fairy, the magic transistor radio, the land and water were similar to those used in the goal version. The voices used were the same, but they said different things. The feature of surprise found in the game version was replaced by having surprise auras that contained animal sounds dotted around the SoundScape.

2.6. Procedure

Thirty children visited the Hewlett-Packard Laboratories with their teachers for the day. Each group of 10 participants were divided into two groups of five, so that the SoundScape was not too crowded to use. The last group was split into one group of 4 and another group of 6, unfortunately the data from the group of 4 was lost. Hence there were only 26 participants in the study. Each group was given a standardised set of instructions prior to starting. These instructions explained what a SoundScape was and that they would be playing with two different SoundScapes. The first three groups started with the goal condition. The last two started with the non-goal condition. Each participant was given 10 minutes on their first SoundScape and 10 minutes to fill in the relevant questionnaire. Then they were then given 10 minutes on their second SoundScape followed by the relevant questionnaires.

3. RESULTS

The participants' responses on the first section of the questionnaire were analysed using a non-parametric statistical test (Wilcoxan Signed Rank test) because of the ordinal nature of the data (see table 1). There were four statistically significant differences between the two conditions. Participants in the goal condition were more likely to want another go compared with the non-goal condition (Wilcoxan Signed Rank test, $z = 3.4$, $p < 0.05$). Participants in the goal condition thought the SoundScape was more interesting than in the non-goal condition. (Wilcoxan Signed Rank test = 2.2, $p < 0.05$). Participants thought that the non-goal condition was more sociable than the goal condition. (Wilcoxan Signed Rank test, $z = 2.5$, $p < 0.05$). Participants thought that the fantasy used in the goal condition was more interesting

than the fantasy used in the non-goal condition (Wilcoxan Signed Rank test, $z = 2.0$, $p < 0.05$).

Table 1: Summary of participants' ratings.

	Questions	Goal		Non-Goal		
		M	SD	M	SD	
1	The SoundScape was very interesting	3.9	0.9	3.3	1.2	*
2	I knew what to do	3.3	0.9	2.9	1.3	
3	I like comparing what I was doing compared to my friends.	3.5	0.5	3.4	1.1	
4	I worked with my friends.	3.0	1.1	3.8	1.0	*
5	I did like the fact that others could see what I was doing.	3.5	0.7	3.5	1.0	
6	I would like another go of this SoundScape	4.3	0.8	2.8	1.5	*
7	I found the island fantasy interesting	3.9	0.8	3.4	1.1	*

* $p < 0.05$

Note. For these items 1 = strongly disagree and 5 = strongly agree.

The participants answers to three open-ended questions were coded using 10 categories based on Malone & Lepper's (1987) theory of intrinsic motivation: (i) goal, (ii) level of challenge, (iii) amount of variation, (iv) level of clarity (i.e. suitability of the instructions or of the feedback), (v) freedom of participant (vi) fantasy, (vii) competition, (viii) collaboration, (ix) Recognition, (x) Cognitive curiosity about the technology and (xi) Sensory curiosity – Sounds, vision, etc. There were also a number of other categories: (i) problems with technology, (ii) general and (iii) positive and negative comments.

The children's responses to the question what they liked about a SoundScape revealed a number of interesting findings. Children in the goal condition made twice as many positive comments compared to the non-goal condition. Five children mentioned that they liked the presence of a goal in the goal version. Six children mentioned they liked the cognitive curiosity in the goal condition. In the non-goal condition, 18 children mentioned they liked the sensory curiosity (sound and vision), compared to only 8 in the goal version.

Children made a number of comments concerning what they dislike about the SoundScapes. There were three features children disliked in the goal version, with 10 citations each, they were technical problems, the level of clarity and the level of challenge. The children commented that the level of challenge was too difficult in the goal version, which reduced their motivation to complete the task. There were a number features the children disliked about the non-goal version. Eight children mentioned there was not enough to do in the non-goal version. Two children mentioned that the lack of goal was a something they missed in the non-goal version.

In response to the question how would you make the SoundScapes more compelling. The children generally stated that there should be a goal in the non-goal version. In both versions of the SoundScape they suggested more variation was needed. For example, one participant suggested the non-goal SoundScape could be improved "if there was something else to do". Areas highlighted for change in the goal version were the level of clarity and technical problems. Other changes suggested for the goal included 15 children mentioning the possibility of including virtual glasses as part of the system.

The final part of the questionnaire gathered data concerning which SoundScape the children preferred and why this was the case. Ninety-six percent (25 out of 26) of the children chose the goal version as their preferred SoundScape. Participants were asked why they preferred the SoundScape they had chosen. These responses were coded using the previously identified categories. The goal version was preferred for a number of reasons. The most common was the presence of a goal (mentioned 9 times). Other common reasons included the amount of variation, for example "there was more to do", and the fact there was a challenge.

4. DISCUSSION

The aim of this study was to explore the use of two theories of what makes an experience compelling in the design of situated digital educational experiences. The findings from the study provide support for both models. Challenge is a key component in these theories for making an experience compelling. Malone writes that it is important not to make the task too easy or difficult because that will reduce the intrinsic motivation of the task. In our study, the children commented that the goal SoundScape was too difficult. We had tried to design the goal version so that it different levels of difficulty and that the children would progress through the first and easy level to the harder second and third level, thus ensuring that the children would all find their appropriate level of challenge. The problem was that the first level was too difficult. Thirteen children did not mange to complete the first level and none completed the task. Although, we failed to design the appropriate level of challenge, the fact that children mentioned that their motivation to play the game was reduced because it was too difficult provides support for the importance of challenge in compelling experiences. Another similarity between the two models was the importance of sensory and cognitive curiosity. For the non-goal version the children mentioned that something they liked was the sensory stimulation and one thing that could have improved the goal version was more sensory stimulation.

Cooperation and competition are components that are present in both models. In children's comments concerning what they liked and what they disliked there was no mention of cooperation or competition. Although, the SoundScapes were not designed to support either a collaboration or competition, the goal version did lead to a form of co-operation. There was an interesting phenomenon of the participants forming a human train when they were looking for the stepping stones. One participant would be at the front looking for the stones whilst the others would be behind. If the one at the front failed the next one would try. There was also some

evidence of competition. The children would compare how far they had got. Further work could be carried out to examine whether collaboration and competition could be supported in SoundScapes and whether they could make the tasks more compelling.

An important difference between the two theories was the presence or absence of a goal. Malone & Lepper's (1987) theory explicitly states that an appropriate goal causes motivation, whereas Hull Reid and Kidd's (2002) theory does not. The main aim of the study was to compare a goal version of the SoundScape with a non-goal version of the SoundScape. Children preferred the gaol version compared to the non-goal version. They found that the SoundScape with a goal was more interesting and they were more likely to want to have another go with the goal version than the non-goal version. More positive comments were made concerning the goal version. The presence of a goal was mentioned as important factor in determining why they liked the game. More negative comments were made concerning the non-goal version and the children mentioned a lack of a goal as negative aspect of the non-goal version. One improvement the children suggested for the non-goal version was to add a goal and to include more sensory stimulation. The overwhelmingly preference was for the goal version and when asked why they preferred the goal version by far the most popular reason was the presence of a goal. So in sum the goal version was found to more interesting and preferred more by the children than the non-goal version. This finding has to be taken in context that we were comparing two SoundScapes and that maybe-different SoundScapes would lead to different findings. Also, it is a very new technology and designers are still exploring the space of possibilities. Furthermore, Hull Reid and Kidd's (2002) theory was developed from studying compelling experiences, which did not have explicit goals. However the issue of the presence of gaols is something that would benefit from further investigation.

There are a number of possible extensions and developments in SoundScape technology for supporting educational experiences. Although as discussed above we did observe some forms of collaboration, the use of headphones in SoundScape technology limited communication and collaboration. The children would often take of their headphones to talk to each other. Further research is required to develop the technology to support communication between participants. Another issue with SoundScape technology is only using audio to communicate information to the users. There is no doubt that it provides a rich experience to the users, however future research should investigate how video images could be used in conjunction with audio information without leading to some of the difficulties discussed in the introduction. We are currently exploring the use of both video and audio in a further study exploring the use of situated digital technologies for educational experiences (Facer et al. submitted).

Another issue this study highlights concerns the use of games to support learning. The tasks we used in this study were experimental tasks and not explicitly designed to support students learning. Therefore, the question is how do we design games to motivate the children to learn skills and develop their conceptual understanding. One avenue we are currently exploring with SoundScape technology, is to design activities which are interesting to children and also provide a positive

educational experiences (Facer et al. submitted). These activities are in the form of a game and the game posses the children challenges, which require them to look for methods of coping and in doing so they acquire new skills. For example, we have developed a simulation of the Savannah where the children play the role of a pride of lions. They face the challenges that a pride of Lions face and in solving these challenges they learn more about being a Lion. The work is still at an exploratory stage, but preliminary findings are promising.

In conclusion, the aim of the study was to design situated digital educational experiences using pervasive and ubiquitous technology informed by theories of what makes an experience compelling. The study found that these theories can be useful in developing compelling experiences and found that the presence of goal appeared to make the experience more compelling.

5. ACKNOWLEDGEMENTS

We would like to thank Erik Geelhoed for all his help with the project and all the children and staff from St Gregory's School in Bath for kindly agreeing to participate in this study.

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