Collaborative virtual environment for conducting design sessions with students with autism spectrum conditions

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ABSTRACT

Young students with autism spectrum conditions (ASC) often find it difficult to communicate with others face-to-face. Virtual reality offers a platform in which students can communicate in a safe and predictable environment where face-to-face communication is not necessary. Participatory design with end-users is an important part of developing successful, usable and enjoyable technology. As designers of technology for young students with ASC, we seek to involve these end-users in the design of software. Therefore, we have developed the Island of Ideas: a collaborative virtual environment (CVE) designed to facilitate participatory design activities with students with ASC. In this paper we report an experimental trial of the Island of Ideas CVE as a meeting space in which a researcher talks with students to find out their views on computer game design and their ideas for new game levels.

1. INTRODUCTION

Involving users in the design of technology through participatory and user-centred design (UCD) methodologies is widely acknowledged as an important step in developing appropriate and usable programs (Lewis, 2006). Traditionally, the involvement of users in the design and development process of technology intended for use in an educational context, has focused on adult users (Scaife and Rogers, 1998). However, over the past 20 years, this process has gradually moved away from seeking this information from proxies such as parents or teachers only, towards obtaining additional information directly from the children themselves (Read and MacFarlane, 2006; Borgers and Hox, 2001; Borgers et al., 2000). There has been a marked increase in research that has involved child end-users in design (e.g. Garzotto, 2008; Hall et al., 2006; Druin and Fast, 2002; Druin, 1999; Bekker et al., 2003). Most researchers now acknowledge the importance of consulting children on technology design as they often have different capabilities and experiences with technology and therefore different requirements (Bekker et al., 2003). Children have been involved in the design process through many different types of UCD activities (e.g. prototype testing activities, workshops, evaluation questionnaires) and through various roles such as user, tester, informant and design partner (Druin, 2002).

The use of technology for supporting and engaging children with autism spectrum conditions has been shown to be effective (Hardy et al., 2002; Barry and Pitt, 2006; Hart, 2005; Battocchi et al., 2008; Moore and Calvert, 2000) and software that has been developed specifically for this user group is on the increase (Williams et al., 2002). However, despite the increasing involvement of children in technology design, the number of cases where children with special needs, and in particular, autism, have been involved are relatively small (Parsons et al., 2002; Benton et al., 2011) and adult proxies (e.g. see Kientz et al., 2007; Leo and Leroy, 2008; Hirano et al., 2010; Falcão and Price, 2010) or their typically developing (TD) peers (e.g. Garzotto and Gonella, 2011) are usually involved instead.

Encouragingly, users with special needs and autism are becoming more involved in technology design projects (Guha et al., 2008; Benton et al., 2011). However, when children with autism are involved in design, their role is usually limited to that of a tester, where they are observed whilst trying out an already existing prototype (Guha et al., 2008). Researchers and teachers observed children with autism in their exploration of...
prototypes to inform the design of the ReaTickles software suite (Keay-Bright, 2007). Similarly, Madsen et al. (2009) reported conducting participatory design sessions with seven adolescents (aged 10 to 17 years) with ASC by observing their interactions with a prototype. Millen et al. (2011) developed and tested a ‘design a game’ method that was adapted to meet the needs of children with ASC through a structured process that was supported with visual aids and prompts. Benton et al. (2011) also tested an adapted participatory design method for generating ideas with children with autism for a mathematics program.

Researchers are faced with a number of challenges to overcome when seeking to involving children with autism in the design process. Children with autism may find communicating their views and opinions difficult, they may have limited imagination skills and they may have difficulties in understanding another person’s viewpoint (Millen et al., 2011). Additionally, they may require more time to understand, accept and adapt to changes (Kärnä et al., 2010) and have limited motivation and a fear of failure (Francis et al., 2009). Children with autism are therefore less likely to be involved in the design process due to these perceived challenges; those authors that do report involving children with special needs in design tend to provide little detail and guidance about the methods used (Frauenberger et al., 2011). The result is that there is very little in the way of recommended methods or guidelines for involving this user group (Parsons et al., 2011; Benton et al., 2011).

Due to the specific needs of children with autism, an adapted or “special” approach is required when seeking to involve this user group (Leo and Leroy, 2008). This is something we have been exploring through our work in the COSPATIAL project (see Millen et al., 2011; Parsons et al., 2011) in which we developed CVEs for supporting students in developing social competence and collaboration skills. In COSPATIAL, CVEs were chosen because they offer a way for students with ASC to communicate without the need for face-to-face communication which they may find difficult (Parsons et al., 2011). This feature combined with the other attractive features of computer technology for children with ASC, motivated us to explore the potential of CVEs for supporting participatory design activities with this user group. To test this idea, we developed the Island of Ideas CVE.

### 2. THE ISLAND OF IDEAS CVE

The Island of Ideas CVE was built using GLU4D technology (an audio-video communication CVE developed at the Mixed Reality Lab, University of Nottingham) and allows users to communicate with each other on a virtual island (Figure 1). It has been designed as a virtual meeting space in which a researcher conducts a participatory design session with children to find out their views on computer game design.

![Figure 1 (left). The Island of Ideas CVE.](image1)

![Figure 2 (right). A student and researcher accessing the CVE from separate laptops.](image2)

A child and researcher can enter the virtual room from separate laptops and communicate with each other via a headset (Figure 2). The users can be represented by either a computer-generated avatar or via “video pods” (Figure 3). Prior to entering the virtual environment, the student is able to choose from a selection of male and female avatars with different coloured hair and t-shirts. The video is a form of video-mediated communication that allows users to view other participants in real-time. Video streaming technology allows the application to capture and distribute a live webcam feed that can then be displayed on the recipient’s pod.

Within the virtual environment there are numbered stations from 1 to 5 positioned clockwise around the island. Different activities or discussions related to game design are carried out at each station. The stations allow the researcher to structure the session in a clear and logical way that help to support the student’s understanding throughout the activity. The student has free movement around the virtual space but is asked to move around the island from station to station with the researcher. Each station usually hosts three boards: a
start board that explains the activity that will be conducted at that station, an activity board where the activity is carried out and an end board that summarises the activity and instructs the user to continue to the next station. These start and end boards correspond to a virtual timetable that is displayed at the first station on the island and further structure the activity and help students recognise what is required from them in each section of the session.

![Figure 3. Representation within the CVE: avatars (left) and video pods (right). (Images blurred to protect student identity).](image)

### 3. EVALUATION

A school-based study was conducted to evaluate the Island of Ideas as a computer-mediated, participatory design resource. The study also examined the influence of avatar representation for supporting students with ASC in reviewing the design of computer games and generating ideas for a new level for the game. The differences between the two types of representation in the CVE posed interesting issues: on the one hand, being able to actually see the student via a webcam may help the researcher to mediate the session and monitor the student’s interest and motivation levels and the novelty of the video pods may be rewarding for the student; on the other hand, however, the student may feel more comfortable and safe when their actual appearance is shielded from the researcher and the pressures of non-verbal communication are removed altogether (Benford and Standen, 2009). It was therefore expected that students would prefer to use the CVE with avatars rather than video-pods.

Twelve students with an autism spectrum condition or Asperger’s Syndrome (age range: 11-14 years; 1 female, 11 male) participated in the evaluation study. All of the students had verbal ability and attended a mainstream school in which they received special support for the impairments associated with their autism which were primarily associated with behaviour, social interaction, communication, imagination and rigidity of thought processes. Each student participated in four 60-minute sessions, one a week for four weeks. The first session was an introductory session in which the researcher introduced herself and the project by completing worksheets with the student. The following two sessions involved the student using the Island of Ideas and engaging in the following activities at the virtual stations:

1. Playing a commercially available computer game;
2. Interview discussion with the researcher, answering questions about design features of the game just played;
3. Drawing ideas for a new level for the game.

During the sessions, the researcher and student entered the virtual environment from separate laptops and communicated using headphones and microphones. For each session a different game was reviewed and the interview was conducted under one of the study conditions (in counterbalanced order), as follows:

- Experimental condition 1. Island of Ideas CVE with avatars: Participants are represented by computer-generated characters or avatars.
Activities or discussions were carried out at each station as follows:

Station 1. Introduction to session: a visual timetable was displayed and the researcher explained the aims of the session to the student. This helped to facilitate the student in understanding what they would be doing and what was expected of them. A photograph of the student’s avatar or video pod (see Figure 3) was taken within the CVE and displayed at this station so that the island became their personal Island of Ideas.

Station 2. Playing the game: a web browser on the island allowed the student to play one of two commercially available games that they would subsequently review. The student was asked to try out the game as many times as they wished in a ten minute period. They were asked to think about what they liked, disliked and wanted to change about the game during the period of game play.

Station 3. Describing the game: the student was asked to explain to the researcher what the game was about using a screenshot from the game to remind them. This board served as an introduction to the next activity.

Station 4.a) Reviewing the game: again, screenshots from the game were used to prompt the student to talk about various aspects of the game and how they could improve them (e.g. rewards, characters). The student (or researcher if the student preferred) could type their ideas on to a text board next to the screenshots.

Station 4.b) Ideas for a new level: it is also at this station where the student and researcher developed ideas for a new level for the game. They were able to draw their ideas using a paint program on the island and a drawing tablet and pen attached to the laptop. The researcher also had a tablet and pen and could draw on behalf of the student if they preferred or if they were particularly struggling.

Station 5. My ideas gallery: the typed and drawn ideas that the student created were displayed on five boards at the ideas gallery. This tool was used to alert the student to the completion of a section of work or to show them their work had been displayed and was therefore valued. The student and researcher reviewed the ideas together and the session was concluded.

The fourth and final session was an evaluation session where the students were asked to critically review the Island of Ideas with the researcher.

4. RESULTS

To understand the usefulness of the Island of Ideas CVE as a tool for supporting participatory design sessions we examined the outputs generated by the children (i.e. whether they were able to generate game ideas) and collected the children’s opinions of the task, the virtual environment and character representation format. These are reported in the following sections.

4.1 Use of the Island of Ideas for participatory design activities

All 12 students completed both sessions (using experimental condition 1 and experimental condition 2 each for one-hour a week apart) and stayed motivated throughout the sessions. This in itself was a positive result as nearly all of the students were described by their teachers as students who find it difficult to concentrate and focus and are easily distracted. This was the first time (apart from a practice session) that the students had used a tablet and graphics pen and they all seemed to find this interesting and exciting to use. At first, some of the students were reluctant to draw as they were concerned that they did not have adequate drawing skills but, as the researcher demonstrated that this did not matter and it was simple to erase parts of the drawing, all of the students were encouraged to join in (see Figure 5 for examples of student drawings). Teachers had commented that a number of the students had poor motor skills, did not like drawing or had “no imagination” and therefore it was encouraging that they did all produce drawings. This may indicate that the virtual surroundings of the CVE can inspire or encourage students’ imaginative side or that using the graphics tablet was sufficiently novel and exciting that they overcame their reluctance.

In previous participatory design sessions with typically developing students and students with ASC (Millen et al, 2011) struggled to generate ideas for a completely new game and even though the activity was heavily structured with worksheets and introductory activities for the children with ASC, this task still proved extremely difficult. For this reason, the children with ASC in this study were asked to generate ideas...
for a new level for two existing games (one game in each session) rather than a completely new game altogether. The students responded well to the drawing activity and demonstrated that they were able to use the structure of the existing game that they had played to generate new content and ideas for the game. One of the existing games involved successfully moving a character from one side of a river to another to collect rewards by jumping from log to log (Figure 4). Using this idea as a template, students generated ideas for new levels for this game such as navigating a character from one planet to another to collect aliens or getting from one side of a sinking sand river to another by using moving cacti as platforms (Figure 5). Students were able to generate a range of ideas for new level environments, obstacles, rewards and ideas for the representation of lives.

Figure 4. Screenshot from one of the games that the students developed new level ideas for during the session (http://www.bbc.co.uk/cbbc/games/way-of-the-warrior-game).

Figure 5. Examples of student drawings of game ideas within the CVE.

Being able to see and review the ideas that they had generated with the researcher at the ideas gallery was motivating for the students and allowed the researcher to ask the student to reflect on their ideas and explain them again. This often generated a clearer explanation of why they had added an idea or object to their drawing as they were no longer focused on the drawing task itself.
4.2 Questionnaire results: student preferences

The students completed a short questionnaire at the end of each session. The researcher read the questions to the student and asked the children to think about how they felt about using the virtual island with different forms of representation: avatars and video pods. The students’ responses were recorded on a “smiley-style” likert scale (Figure 6) from 1 (“Not at all”) to 5 (“Very much”). Each question and the results obtained are shown below.

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Not very much</th>
<th>A little bit</th>
<th>Quite a lot</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 6. Smiley likert scale (adapted from Read and Macfarlane, 2006).

Q1: Did you like using the avatars / video pods on the virtual island to talk to the researcher about game design today?

This question was asked separately for avatars and video pods at the end of the corresponding session. The results show that the median rating for the avatar condition was 4 (IQR = 1.75) and the median rating for the video pod condition was 5 (IQR = 0.75). This indicates that there was a slight preference for the video pod representation over the avatar representation when the sessions were rated in isolation.

Q2: A) Did you like using the avatars on the virtual island to talk to the researcher about game design in week 1? B) Did you like using the video pods on the virtual island to talk to the researcher about game design in week 2?

The student was asked these two questions together after completing both of the CVE sessions and, again, their responses were recorded separately for each mode of representation on the smiley scale (Figure 6). The median score was 4 for both the avatar and video pod condition with the interquartile range for avatar being 2 and 1.5 for video pod. The ratings for each mode were similar with very few students commenting negatively on their experience of using the CVE. Only one student gave a negative rating for the avatar condition (they had reported feeling tired on the day and so this may have affected their opinion).

Q3: Did you prefer talking to the researcher about the game you played in week 1 using the virtual island and the video pods to talk to each other or in week 2, using the virtual island and the avatars to talk to each other?

The students were also asked to indicate which mode or representation they preferred overall after experiencing both conditions. Figure 7 shows the format of this question presented to students who experience the CVE using the video pod in week 1 and avatars in week 2. The results showed that 5/12 students stated that they preferred using the CVE with the avatars and 7/12 students preferred using the CVE with the video pods. The outcomes of the study suggest that the Island of Ideas shows potential as a tool for supporting PD with children with ASC as all children were enthusiastic and motivated during the sessions. Initial results suggest that there is a slight preference for using video pods when students with ASC participate in participatory design sessions on the virtual island.

4.3 Student review of the CVE

The review session lasted one hour and was structured by the researcher with a timetable and pre-prepared worksheets as these help the student to focus. The session focused first on the differences between video pods and avatars and what the student thought of each one and how they would improve them (Figure 8- left). Next, the student and researcher progressed on to a worksheet where the researcher talked with the student about their opinions of the Island of Ideas and how they would improve the Island (Figure 8 – right).
Figure 7. Format of question for overall preference (question 3).

Figure 8. Evaluating avatars worksheet (left) and evaluating the Island of Ideas worksheet (right)

Table 1. Examples of comments from students during the evaluation session.

<table>
<thead>
<tr>
<th>Avatars</th>
<th>Video pods</th>
<th>The Island of Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I preferred this one because you can choose the clothes”</td>
<td>“Useful because it shows your face and expressions”</td>
<td>“Should be able to go somewhere – sail to another islands”</td>
</tr>
<tr>
<td>“Not enough variety”</td>
<td>“It looks cool!”</td>
<td>“Play more games from a game list to get inspiration”</td>
</tr>
<tr>
<td>“Should be able to customise”</td>
<td>“You know who you are talking to”</td>
<td>“Choose from a list of backgrounds: Castle Island, Grand Canyon Island, Cruise ship”</td>
</tr>
<tr>
<td>“The mouth, arms and eyes should move when you’re talking”</td>
<td>“Video pods are better because you can see the person”</td>
<td>“Customise the island – add objects, trees, plants”</td>
</tr>
<tr>
<td>“Likes being able to choose the colour of the [avatar’s] top”</td>
<td>“Some shy people might not like the pods”</td>
<td></td>
</tr>
<tr>
<td>“I preferred this one because I could mess about without [the researcher] seeing”</td>
<td>“Easier to know what we’re doing and how we’re feeling”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“More like real life”</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows some examples of student ideas for improving each feature. Most of the students thought that they should be able to customise the video pods in some way e.g. changing the colour, adding patterns, adding their name to the pod. Although the students were able to choose the hair colour and t-shirt of their avatar, most students felt that this level of customisation was not enough and that they should be able to customise the avatar by choosing its hair colour, clothes and facial features. Some students suggested combining the avatars with the video pods by creating an avatar that also had on it a video port e.g. on the head of the avatar. Common suggestions for improving the virtual island were: allow travel to other virtual
islands, include more characters on the island, and allow users to explore the virtual towers and customise the appearance of the island.

5. CONCLUSIONS

The use of computer-mediated participatory design sessions for engaging with students with ASC shows some potential. The students enjoyed using the technology and seemed to find the Island of Ideas exciting and motivating. All students participated in the full one-hour sessions and generated game ideas and drawings. This is particularly important as all of these students were described by their teachers as having difficulties with lack of imagination, motivation and difficulties with attention that are common amongst students with ASC. This is very encouraging and suggests that the Island of Ideas is a beneficial environment for these types of activities. Only slight differences were observed in student preference between the two types of representations within the CVE; 5 preferred to use the CVE with avatar and 7 preferred the video-pod. This result is extremely interesting as it was considered that the video-mediated condition may be less popular with ASC children. In a study of the opinions and attitudes of adults with high functioning autism or Asperger’s Syndrome (AS) towards internet communication, Benford and Standen (2009) found that people with autism favoured text-based internet communication (e.g. emails and chat rooms). It was suggested that the reason for this was removal of the stressful nature of face-to-face interactions. According to Benford and Standen (2009), a rise in video-mediated types of communication in the future may diminish the positive features of computer mediated interactions for users with ASC. However, the findings from the current study and other recent studies that have found positive responses from children and adolescents with ASC and AS (e.g. Baker and Krout, 2009) suggest that the younger autism generation may be more accepting of computer-mediated video communication. However, it could be that the current task and novelty of the CVE were sufficiently motivating for the children who participated in the study to overcome reluctances in video-streamed communication settings. Overall, the study showed that students with ASC can be involved in participatory design activities and can provide ideas, both for development of new software games, and for improvement to computer-mediated environments. All of the students involved in this research put forward ideas for ways in which the CVE and forms of representation could be improved and therefore these should be explored in future work.

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