The Development of Educational Collaborative Virtual Environments for Children with Autism

L. Millen¹, R. Edlin-White¹ and S. Cobb¹

¹VIRART (Virtual Reality Applications Research Team), Human Factors Research Group, Manufacturing Research Division, Faculty of Engineering, University of Nottingham, University Park, Nottingham, NG7 2RD

E-Mail: emxlm@nottingham.ac.uk

1 Introduction: Technology and Children with Autism

The use of technology in the education of children with autism has positive and beneficial effects. There are few adequate purpose written solutions on the market but much ongoing research work. In addition, there is very little methodological guidance and human-computer interaction guidelines for the development of technology for this user group (Moore et al., 2007). Given the well established benefits in engaging users in a participatory, user-centred design process when designing technology (Muller, 2002; Lindgaard et al., 2006; Vredenburg et al., 2002), we should investigate whether the same benefits are available for children with ASDs. There has been limited research thus far into how we can involve children with autism in this process (e.g. see Piper et al., 2006; Keay-Bright, 2008).

1.1 What is Autism?

Autism is a life-long, developmental disorder primarily characterised by impairments in social skills, communication and imagination (Happé & Frith, 1996; Wing & Gould, 1979; Wing, 1996). There is huge variability in the level of these impairments and autism is usually described in the context of Autistic Spectrum Disorders (ASDs), a wide-ranging framework of diagnosis ranging from low functioning individuals with no verbal communication at all, to high functioning individuals (e.g. those with Asperger’s Syndrome (AS)) who may have an average or above average IQ. There are estimated to be over 130,000 children with ASDs in the UK (NAS, 2009). Most of these children require special educational provision either in mainstream schools or – for the more highly impaired - in specialist schools, catering for autistic impairments by providing high teacher pupil ratio, a calming atmosphere, clear and familiar structures and routines and engaging, customisable learning activities.

1.2 Why Technology for Children with Autism?

Research has indicated that the use of computers and computer technology for children with autism has positive and beneficial effects. ‘Parents and clinicians regularly report that children with autism are drawn to technological devices’ (Goldsmith & LeBlanc, 2004: 166), and ‘there is mounting evidence that computer-based interventions are beneficial to pupils with autism’ (ibid. p. 170). Computer technology as a tool for supporting learning is valuable and motivating for children with autism (Goldsmith & LeBlanc, 2004; Hardy et al., 2002; Barry & Pitt, 2006; Hart, 2005; Battocchi et al., 2008; Moore & Calvert, 2000). In brief: ‘children with autism like computers’ (Hardy et al., 2002: 1).

There are a number of features of computer technology which offer considerable benefits for use with children with ASDs. It makes fewer social demands and is predictable and consistent leading to more successful interactions (Battocchi et al., 2008); it can provide the user, or supervisory user, with a great deal of flexibility to customise the activity; it can present activities repeatedly; it can simulate situations which would be unsafe or unacceptable in real life; it can customize to a pupil in areas such as difficulty, speed or sensory stimuli; it can focus attention and reduce distraction; it can be controllable by the pupil; it can use imagery rather than language (Putnam & Chong, 2008; Bosseler & Massaro, 2003; Lanyi & Tilinger, 2004; Dautenhahn, 2000; Parsons et al., 2004).
Despite these advantages, there is a noted lack of software which is designed specifically for children with autism. Software for general special needs education often has 'significant shortcomings' for autism and may need considerable adaptation (Moore et al., 2007; Hardy et al., 2002; Putnam & Chong, 2008).

2 Design for ASD experience within VIRART

The Virtual Reality Applications Research Team (VIRART) and associated partners have explored issues relating to design, development and evaluation of virtual reality virtual environments (VR/VEs) for children with autism. This has included consideration of how children with ASD can be included in the design process, as well as review and development of usability guidelines for technology to be used by children with autism.

2.1 AS Interactive: Developing Virtual Environments for Social Skills Training in users with Asperger’s Syndrome

AS Interactive was a three-year multi-disciplinary project funded by the Shirley Foundation to explore the feasibility of using virtual environments for rehearsal and practice of social skills in young adults with Asperger’s Syndrome (Cobb et al., 2002). As a new application for an emerging technology, there were many open questions about how we should design VEs for this user group and whether or not VEs were a suitable medium for learning (Parsons & Mitchell, 2002). A user centred design process was applied in which different stakeholders informed different stages of design and development of the VEs (Neale, Cobb & Wilson, 2002). A variety of methods to obtain user input to the review of VE content, layout, interface and functionality were explored (Neale et al., 2003). These included written storyboards reviewed by domain professionals (P) together with VE developers (V) to establish the learning objectives and required interactions for each task. Pictorial storyboards reviewed by P and V with the addition of users (U) and user group facilitators (F) informed the visual representation of the VE, interaction methods and use of user viewpoints. 3D low-tech models, reviewed by P, V, U and F were used for mapping the 3D layout of the VE and movement of users within it and to determine the navigation and interaction requirements to perform tasks. Acting and role-play methods informed assessment of the efficacy of the VE layout and the need for auto-viewpoints at key points of interaction. VE prototype reviews and on-line walkthroughs, conducted by U and F were used to assess all aspects of VE design (content, layout, graphics, colours, complexity, interaction methods and feedback) and to identify where and how users would benefit from mediation and support from a teacher or facilitator.

A combination of experimental and qualitative evaluation methods was applied in the AS Interactive project. Experimental studies conducted to assess use and understanding of single user VEs found that people with ASDs can use VEs and have a basic understanding of their representational nature (Parsons et al., 2004) although some students with weak executive function skills required support from a facilitator to help them complete tasks (Parsons et al., 2005). Observation of teachers using the VE to support teaching of specific skills in the classroom indicated that they used it as a visual prompt to promote discussion about the social scenario and why the virtual characters behave as they do (Neale et al., 2002). Teachers reported that the VE helped students to talk about their anxieties or worries in dealing with these situations and follow-up case studies showed that rehearsing with the VE gave students confidence to do things independently in the real world (Wiederhold, 2004). The results suggest that VEs are a suitable medium for ASD learning, but that more work is needed to understand how best to design VEs for independent use by users with ASD (Cobb et al., 2009).

2.2 COSPATIAL: Collaborative Virtual Environments for Interaction and Learning in Children on the Autism Spectrum

VIRART are currently partners in COSPATIAL; a 3-year multidisciplinary, collaborative project funded by the European Commission through the FP7 research programme exploring the use of innovative technologies for supporting the development of social competence for children on the autism spectrum as well as their typically developing peers. Building upon the user-centred design methods applied in the AS Interactive project, COSPATIAL is using a somewhat modified participatory design framework (Muller, 2002) in which the design team includes teachers as equal design partners but not currently involving pupils. This has involved observational visits from university researchers to two specialist autism schools, many discussions and semi-formal interviews, and most notably a series of facilitated workshops where specialist teachers from autism and
mainstream schools have engaged in creative structured discussions with researchers and have been envisioned with technological demonstration.

COSPATIAL seeks to utilise collaborative virtual environments (CVEs), rather than the single user VEs developed previously in the AS Interactive project (Cobb, 2007). Thus, although we can build upon the outcomes of the AS Interactive project in our understanding of design and usability of VEs, the design decision space for development and application of CVEs for users with ASD is still open and unexplored; we are still working with a relatively new and complex technology that itself has few standardised methodologies and guidance for development.

### 3 Design Challenges

Designing educational software using VR for children with autism poses a number of design challenges. There are few recommended guidelines and methodological procedures for the design of technology children with ASDs (Moore *et al.*, 2007). Human Computer Interaction studies offer several user-centred design approaches including contextual design, participatory design, inclusive design, accessible design etc. A truly inclusive process would involve users throughout but there are few precedents for this (see 4 below) and many challenges (see 4.1 below). A design process for this user community with their profound and varied neurological impairments will be considerably influenced by their special needs (Woodcock & Woolner, 2007). For educational software there is also a need to consider Instructional Systems Design based on appropriate education theories and paradigms (Barry & Pitt, 2005; 2006).

Because it is difficult and time consuming to elicit requirements, there is much value in establishing generic design guidelines and requirements. Two studies (Millen, 2007; Edlin-White, 2009) within VIRART set out to develop general usability guidelines, generic requirements and methodological guidance for the design / development process for this purpose. A literature search at that stage found few sources of general guidelines, with limited relevance. For example, Grandin (2002) provides 28 “teaching tips for children with autism” some of which are relevant to ICT; e.g. avoid sudden loud sounds, some sing better than they speak, some don’t understand line drawings, some work better when keyboard is near the screen (Grandin, 2002). Van Rijn & Stappers (2008) in developing an interactive toy for home-based language learning for autistic children elucidated 8 “Guidelines”, e.g. provide structure, let them feel in control, reward them with sensory experiences, utilise their eye for detail, let them use their whole body. Both of these contain huge insight but are quite general. Barry and Pitt (2005; 2006) note lack of guidelines and report work whose ultimate aim is to provide guidelines, but these are not yet available. A large study has been conducted by Woodcock & Woolner (2007) into requirements for a multisensory room for use by children with autism. Although detailed findings have not yet been published, preliminary findings identify four themes for design consideration: accommodate sensory variability, avoid inappropriate or easily damaged materials and objects, address the whole ASD spectrum, and provide repetition.

Review studies conducted by the authors (Millen, 2007; Edlin-White, 2009) have identified some guidelines based on field observations and interviews at two specialist schools for pupils with autism, interviews with parents, teacher workshops, and study of published literature. Both studies also identified benefits of a more user-centred design process and appealed for involvement of children with ASDs during the design and development lifecycle of the technology. Millen (2007) produced a set of fifteen usability guidelines covering the use of sound, language, content and graphic display. Examples include:

- Sound, including music, should be optional or at least include a simple volume control.
- Software should not rely heavily on language and text for instructions and commands.
- Software should provide a means of ordering activities and recording completion.

Edlin-White (2009) built on the above and produced a General Requirements document providing 50 requirements. Due to the huge variability of the pupils, many of these “requirements” were not very specific and more like extra guidelines. Some examples of necessarily unspecific requirement areas are:

- Use appropriate devices, taking account of pupils’ fine motor skills, understanding of cause and effect for that particular device, ability (for some devices) to conduct manual actions while looking at a remote display device, and need for personal space and privacy.
- Activities should be repeatable with sufficient variation to maintain interest, to support learning reinforcement and knowledge retention, and ideally also to enable generalisation and transferability of skills to a variety of real life situations.
- Competitive elements (such as scores) should be omitted or removable by the teacher.
- Solutions should as far as possible be quickly and easily customisable by staff to cater for the variability of pupils in a class.

General guidelines and requirements can go some way to reducing the work in eliciting specific requirements for learning activities, but there will be different requirements for different educational objectives.
and for different ages and abilities of user. For this reason, there is still a need for include members of the user group in the design process of technology. However, little work has investigated how we can involve children with ASDs in the design process and therefore no guidance exists. Further work is needed to understand how we can involve children with autism in the design process.

4 Inclusive Design: Involving Children with ASDs in the Design Process

The next stage of work, which will form the basis for the first author’s PhD, will carry these issues forward and aim to address the issues surrounding how to involve both teachers and children with ASDs in the design and evaluation process. The need to include users in the design of technology has been advocated by many (e.g. Lewis, 2006). Fischer & Sullivan (2002: 198) state that ‘When designing for persons with disabilities, participatory design is not optional, but essential’. Parsons and Mitchell (2002) comment that members of the population with autism are rarely part of the development process of software leading to products which are inadequate. They state that ‘User-centred design methodologies...address this concern somewhat because representative users are included in product design and development from the start’ (Parsons & Mitchell, 2002: 437). The development of ASD specific technology may be influenced and guided by various important stakeholders, e.g. parents, teachers, funding bodies etc, who can offer different viewpoints and understandings to the design and evaluation lifecycle. However, this process should not ignore the potential contributions of the primary user: the child with ASD. These are the stakeholders who ‘are those least able to articulate their views and influence outcomes, and could therefore easily be under-represented in the discourse about the nature and purpose of learning’ (Edlin-White, 2009: 35).

There are examples of typically developing children being involved in such a process, and Summers et al. (2003) provide a summary of the challenges and benefits. Cognitive disabilities create an extra challenge which is increasingly being met. Over 10 years ago Cobb et al. (1998) involved adults with learning impairments. There have also been examples of children with cognitive disabilities being included to lesser or greater extents in design: Parsons et al. (2000) involved a Collaborative User Group of adults with AS and a Participant User Group of adolescents with AS at various stages; Piper et al. (2006) involved pupils with high functioning autism and AS in a participatory design approach as did Parés et al. (2006) in the MEDIATE project; Kirijian et al. (2007) involved 6 children with Down’s syndrome who were considered part of the design team in user evaluation of prototypes; Keay-Bright (2008) involved ASD pupils as co-designers in a ‘democratic and participatory approach’. However there is as yet little or no literature documenting or justifying the methods and techniques used in participatory, user-centred design with children with ASDs.

As part of COSPATIAL we have begun to experiment with ways in which we can generate discussion and ideas with our design partners, teachers. Collaborative workshops are used to offer a fruitful context for generation of ideas. The early workshops established the range of educational objectives (mainly collaborative skills of various sorts) and the specific range of pupils to target. At the most recent workshop, resulting design concepts for activities or “serious games” were presented to the teachers for discussion. These concepts took the form of cartoon style depictions that represented the general characteristics which would form the activity. This format seemed to relay the concepts effectively and generate interesting and collaborative discussion amongst partners. Clearly, this form of presentation has potential benefits for use by children with autism as it goes someway to overcoming language barriers and problems surrounding conversational skills as well as providing interesting, visual stimuli to motivate the child. However, the effectiveness of this method is not obvious and needs to be examined; children with autism sometimes encounter difficulties when required to focus on images, especially those with a lot of detail. Evaluation and consideration of the value of this technique for involving children with high functioning autism will be carried forward.

4.1 Research Questions and Issues

As briefly mentioned previously, children with autism have a number of cognitive characteristics which may have implications when seeking to achieve user involvement with the design process. Some of these characteristics are (Hardy et al., 2002; Wing & Gould, 1979; Wing, 1996; Siegel, 2003; Baron-Cohen, 1996):

- limited language or communication skills – this characteristic requires a considered approach when trying to involve the user in the process, particularly when attempting to generate and evaluate design ideas and eliciting user opinion;
poor imaginative skills – this could cause potential difficulties, for example, when using low fidelity prototyping which requires the user to use their imagination skills to envisage the final product;

rigidity of thought processes - People with autism find it difficult to be flexible in their thought processes and thus any changes to their environment or routine can prove difficult for them to understand or adapt to. This has implications for arranging sessions and disrupting routines;

“Theory of Mind” impairment: the idea that people with autism often find it difficult or impossible to imagine another person’s mental state and perspective – this poses the issue of whether a child with autism would be able to offer opinions based on their knowledge of their peers;

learning difficulties – IQ or general level of ability or understanding may not be sufficient when dealing with the concepts required.

Similar challenges were encountered by Piper et al. (2006) who found it took a long time to build rapport with students, and found group interviews worked better than one-on-one.

These considerations will be investigated as part of the PhD under the broader context of developing methods for how we can involve users with autism in the design process. The PhD will use previous work surrounding the issue of design guidelines for developing technology for children with autism (Neale, et al., 2003; Millen, 2007; Edlin-White, 2009) as a starting point and aim to build, develop and extend the issues considered with a specific focus on how this relates to the development of collaborative virtual environment. The work will aim to consider the specifics and logistics of how to involve the whole user group (children, teachers and parents), such as:

- How can we engage children with ASDs with the process?
- At what age and ability are children with ASDs most able to participate?
- At what stage in the design process should user group members be introduced to the process and become participatory members?
- What are the barriers to involvement and how can these be overcome, if possible?
- Where and how should meetings of design partners take place?
- How should the presentation of these meetings be arranged?
- How can the outcomes of involvement of the user group be fed into the design?
- How can the evaluation of prototypes occur? What are the potential gains and risks of introducing prototypes into the classroom?

It is hoped that the output of the PhD process will be a set of methods, guidelines and tools for involving teachers and children with ASDs in the design of technology will be produced.

5 Summary

Technology has great potential as an educational tool to teach social skills and collaboration to children with autism as well as being stimulating and motivating. Despite this, there has been a lack of research into how technology can be designed inclusively with the input of the target user group, in the case of this work, the supervisory adult and the child with autism. Processes, guidelines, methods and tools are needed to guide the development of technological solutions that are not only state of the art but also usable, effective and therefore educationally valuable. User-centred and participatory design principles would expect the user to be involved in stating and negotiating requirements, jointly making design decisions and trade-offs, evaluating prototypes etc. It is unclear how this can best be achieved with such a user population, and unclear what methodologies, processes and principles are most appropriate. The first author’s PhD will focus on these issues and aim to develop methods, guidelines and processes for the development of technology, in particular collaborative virtual environments, for children with high-functioning autism.
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References


Autism is a developmental disorder characterized by impairments in social reciprocity and communication, and the presence of restricted or repetitive activities. Onset of autism is before the age of three. The etiology of autism is organic, though no single pathologic event has been identified as uniquely or universally associated with the disorder. Retrospective parental report: Retrospective parental reports have provided important information about the early development of children with autism prior to their first referral for diagnosis. However, retrospective reporting is prone to several types of distortions, such as inaccurate recall and reporter bias, which require that their results be interpreted cautiously.

REFERENCES

A review of the literature supporting the use of single-user virtual environments to help adolescents with autism learn imported in the Virtual Theatre interface through the option appropriate social communication skills." Computers in Human Behavior. Add a character, in order to produce a performance in social Volume 29, Issue 5, Pages A17–A24, in press. circumstances. Child characteristics such as severity of autism symptoms are thought to determine educational placement. However, where a child lives may significantly impact whether they are placed in an inclusive or segregated classroom, a national analysis suggests. There was considerable variation among states in placing students with autism in inclusive, mainstreaming, self-contained, and separate schools. Specifically, states varied substantially in the percentage of students with autism educated in each setting, with some states consistently favoring inclusion (Colorado, Connecticut, Idaho, Iowa, Minnesota, Nebraska, North Dakota, West Virginia, and Wisconsin).