The Reactive Colours Project: Demonstrating Participatory and Collaborative Design Methods for the Creation of Software for Autistic Children

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Abstract: This paper demonstrates the importance of participation with end-users and interdisciplinary collaboration with experts, to the design process. The context for this study is interaction between autistic children and computers in education. Whereas computers in education are conventionally associated with task-based learning, my research uses the computer as a tangible interface for embodied play activities. I make two claims with regard to the participatory design process. (1) There is, I argue, an important relationship between the participatory design process and the design of play for autistic children. End-user participation in this context allows the highly particular responses and reactions of autistic children to be recorded and included in the evolutionary design process. (2) The interdisciplinary approach to collaboration presents a challenging paradox for designers, as it requires both imaginative and empirical design methods. Whilst it is often critical to have statistic analysis to satisfy scientific approaches, it is of equal importance, within this area of research, to understand the idiosyncratic behavioural patterns of individuals on a spectrum of autistic difference. In this paper, I (a) set out my work on the computer as a tangible interface for embodied play, (b) demonstrate, through examples of the Reactive Colours research methods, how autistic children claim the embodied play environment as their own, and (c) describe how this appropriation by the children and interdisciplinary collaboration is incorporated into the design process. I also indicate the benefits which the tangible interface has for enhancing the learning capacities of autistic children.

Keywords: Participatory Design, Interdisciplinary Collaboration, Tangible Interfaces, Play, Autistic Spectrum

Introduction

This paper will focus on the successful collaboration between young children on the autistic spectrum at a Special Education Needs (SEN) School in Wales, UK, together with their teachers, families and experts in a variety of related interdisciplinary fields, which has resulted in the ReacTickles software and the creation of the www.reactivecolours.org project website.

The research aims of the project have been to promote relaxation, encourage spontaneous play, and support learning for children on the autistic spectrum. By using the inherent flexibility and controllability of digital media to enable individualised sensory experiences, the project team realised that computers, when enabled as an embodied play experience, had the potential, beyond that of function, to support the inclusion of the most severely anxious autistic individuals.

A key issue in achieving this aim was to define a methodology that placed the target population at the centre of all design and development.

The participatory design methods used for the project represent a synthesis of methodologies undertaken by other researchers, most notably Druin (1999), whose work focuses on the co-operation of children in the design of technology and Dishman (in Laurel, 2003) who has undertaken projects which involve the ageing population as participants in the design process.

The Reactive Colours project has extended these methods by inviting autistic children and their teachers to contribute to the design of the software during critical stages of development. Although the methods were time consuming, partly because the problems are so complex but also the need to become accepted by the participants, they ensured that any proposed solutions were designed from the point of view of the autistic child rather than the technology.

Background

This section presents an overview of the core principles of participatory design and how these approaches have influenced the Reactive Colours project.

Participatory Research

Participatory design requires that people, whose lives stand to be affected in some way by the outcomes of the research, are given the opportunity to identify themselves within the objectives of the research. There is no exclusive group in a position to determine the interests of others; the process is democratic and visible to all (Friere, 1974). Conventional methods...
which emphasise statistical data gathering do not put research in the context of a creative activity and are unlikely to result in something new and useful which does not already exist. Empirical methods rarely include the spontaneous and voluntary involvement of the target population and the possibilities that may emerge from allowing for the unpredictable are frequently missed. The way in which autistic children interact cannot be presented systematically; therefore gaining understanding through their actions, for example, body activities, expression, and language was paramount to the research.

This presented a significant challenge, many autistic children do not use verbal language to communicate and find the minutest change in their routines extremely painful; however becoming accepted by this group was crucial and so the methods had to be very carefully adapted. Direct knowledge elicitation techniques were avoided as they could create stress and anxiety.

Although other research projects involving participation and collaboration with autistic end users exist (Parsons et al., 2000) linguistically less able children (and adults) are rarely represented and those with the severest social and communicative dysfunctions tend to be disenfranchised by power shifting to the more socially able autistic people. There has been resistance by some researchers to include less able children in participatory research, lack of social competence being used as the delineating factor for exclusion. However, this question of competency arises from the perspectives of requirements and task and is not a component of the Reactive Colours experiential research, as competence for these children is different from, not less than, their more developmentally able peers.

An influential researcher in the design of software for children, Druin’s research presents a number of strategies for including children in the design process. The roles children may play include user and tester; in this capacity they are generally required to test prototypes, which are observed in later stages of development to assess usability and engagement. This process has limitations, as it does not recognise that children are inventive, imaginative human beings capable of interacting with technology in ways that are unpredictable. There are, however, benefits from involving children as testers, the process can be managed efficiently, with minimal interruption to school schedules, and where strong relationships with teachers are fostered, designers may have an opportunity to further test as the work evolves.

The Reactive Colours methodology proposed that autistic children should become key informants (Druin, 1999) in the design process. This meant that whilst adults were ultimately responsible for decision-making, contributions made by children throughout, had significant impact on the both the process and outcomes of the research. Druin’s work proposes that with the appropriate amount of guidance, children may have an equal stake in decision-making as a design partner. Some of these methods, which include brainstorming, sketching, interviews and other ‘low-tech’ development activities, would have been unrealistic for the target population of autistic children aged 4-7, their difficulties in social situations being so profound. However these methods were successfully undertaken with teachers and support staff during the earliest stages of the research.

The visibility of the design process was reported to be highly educative and valued and served to lift self-esteem and confidence in children, parents and staff. Of equal significance is the boost in motivation for the design team who were met with enormous warmth and delight when they worked directly with participants, as each iterative phase of development had so evidently produced something new, which reflected the contribution of the children.

The participatory methods described in this paper are not presented as an alternative to traditional methods, but to question whether new methods can evolve from these parameters to close the gap between the empirical nature of the researcher and the ‘researched’.

ICT and Tangible Technologies
Within this paper our concern with technology is in the context of:

- Information Communication Technology (ICT), specifically, the role of computers for young children.
- The benefits of computers for autistic children.
- How the ReactTickles software can offer a tangible, playful approach to learning that is developmentally appropriate for autistic children.

The Role of Computers for Young Children
The issue of technology use with young children is hotly debated, on one side there is a view that computers can exhaust cognitive resources and are thus detrimental to health and learning (Healy, 1998), whilst advocates such as Plowman and Stephen (2003) have conducted many studies which promote technology for young learners where the interaction is guided and involves the sensitive sharing of experience with others. Papert (1996), and Pesce (2000), have identified that computers can represent a medium for social and intellectual development, particularly when playful exploration underpins task. This argument is directly opposed in the work of Levin and Rosequest (2001), who suggest that individualised and open-ended opportunities for play are inhib-
ited by the limited and repetitive operational actions of the technological experience.

Much of this debate is based on the assumption that most activities will be located on a small screen and thus cannot be manipulated and explored in the same way as objects in the physical world, which would be more developmentally appropriate for young children. However, the emergence of new types of computer technology has encouraged multimodal forms of interaction, which are closer to the physical play experiences that dominate the development of early play. Opportunities for imaginative, sensory and manipulative play which evolve from the exploration of objects though their physical attributes can be encountered in these tangible technologies (O’Malley C & Stanton Fraser D. 2005).

Interactive whiteboards, particularly the touch sensitive boards manufactured by Smart Technologies™, are an example of this type of technological advance, which is becoming widespread throughout schools in the UK. Whilst tangible computing breaks with the notion that the role of computers is to handle textual information and allows for the direct manipulation and feel of a system through experience, much of the software used with interactive whiteboards fails to maximise on the sensory learning potential enabled by the ability to perceive and manipulate information through one sense; point and click, drill-style exercises dominate the market. In this context, the interactive whiteboard has simply become a digital blackboard.

When teachers first experimented with the ReacTickles software the levels of playful engagement and motivation noted were startling and prompted the widespread use of the software on Smart™ interactive whiteboards even though the earliest ideas were to develop software for desktop computers.

Computers and the Autistic Child

For the purpose of this research it has been necessary to consider these discussions in the context of the particular target group – young autistic children aged four to seven years in SEN schools. Preliminary research conducted by the Reactive Colours researcher using interviews and questionnaires revealed that some children had used computers at home prior to beginning full-time education but most would be experiencing a range of educational technologies for the first time at school. Of the parents whose children were already using computers some expressed concern that whilst using the computer their child became intensely focused and would not participate in other activities.

One of the prerequisites of a positive learning environment is the sharing of activities, particularly waiting, turn-taking, mirroring and co-operation and the ability to recognise the intentions of others (Jordan, 1990). For most autistic children these types of joint experiences are difficult, as they require an awareness of situations that are often outside their very tightly focused range of sensory and cognitive interests.

This narrow range of interests, otherwise known as ‘monotropism’, is one of the diagnostic criterions for autism, so the facility to make areas of interest shareable can assist in both communicative functioning and creative self-expression (Murray, Lesser and Lawson, 2005).

Research has evidenced that, for children on the autistic spectrum computers offer a predictable, controllable and highly perfectable medium where many of the multi-sensory inputs of the real world can be reduced (Murray and Lesser, 1997; Parsons, 2000). In particular they have been shown to assist communication by providing a routine for turn-taking and waiting which in the course of face-to-face interactions would be governed by understanding the intentions of others through language and gesture. For autistic children this represents a significant benefit, as the many layers of interpretation required in face-to-face communication may cause confusion and anxiety. For most children the computer can provide a safe exploratory space for creativity and imaginations where they will find their own interesting and novel way for interacting, without fear of failure (Dix, 2003). For the autistic child, this universal appeal of computers can assist in the inclusion of the most anxious of individuals.

Rationale for the ReacTickles Software

This creation of a neutral ‘space’ via the computer screen or interactive whiteboard has provided a foundation for the evolution of the ReacTickles play experience.

Structure and routine are important to foster creativity and imagination in play (Vygotsky 1978; Piaget, 1962, 1945) and are particularly essential for autistic children (Sherrat, 2002, 1999). This presented an interesting dilemma for the designers whose early concept ideas had been based on the notion of freedom and autonomy in interaction. However many unstructured ideas were dismissed as they caused confusion and children did not feel motivated to explore.

With this in mind, the rationale for the ReacTickles software has been to encourage tapping, smoothing, and circling, using the keyboard or mouse, and to use these modes of interaction to encourage the child to explore the technology rather than be dominated by it. The designers were inspired by the discovery, through observation and interviews, that the objects children found most playful were
spinning tops, Slinkies™, lava lamps, glow balls and kaleidoscopes, all of which offer repetition and reward through touch.

Recreating playfulness involved the deconstruction and analysis of the ‘real’ experience to determine which elements foster the enjoyable sensation of repetition, pattern and similarity, but rather than this being a visual reconstruction of a physical toy, the design focused on the sensory qualities of interaction.

Key interactions such as pointing, choosing, clicking, dragging, pressing keys and vocalising are associated with performing a function with computers. In the design of ReacTickles these are elements of embedded action that do not require mastery, instead they are used to prompt a sense of curiosity which can lead to motivation, attention, and intentionality.

An influence on the rationale for the design of the ReacTickles software has been the understanding that repetition, continuity, sound, smell or touch (Winnicott, 1982), are all characteristics of play which are non-goal orientated, these actions form the foundations of early child development and are often linked to a favourite object. Children on the autistic spectrum characteristically enjoy engaging in repetitive actions because of the opportunities this gives them to predict and potentially control their environment (Jordan, 2003).

This theory has been key to ensuring that the ReacTickles software can support children as they face the challenge of changing social and technological environments in their early school years.

**Participatory Design Methods**

The Reactive Colours model has a four stage cycle iterative cycle:

- Research
- Inspire
- Listen
- Develop

The project has four main stages and the Research-Inspire-Listen-Develop model has been applied at each stage. The first stage of feasibility involved teachers and children helping the researcher define a positive playful environment that could be both relaxing and motivating for children and which could be seamlessly integrated into the school curriculum. This feasibility study led a successful proposal for funding from the National Endowment for Science and Technology Awards (NESTA) which supported the addition of two designers into the team. The design phase that followed funding centred on the integration of ideas from the design team, consultants, and teachers together with observations of children in free-play activities to arrive at a design concept. The implementation phase required the team to consider the goals of the project very carefully and to develop many of these ideas into a series of prototypes, each version accommodating more design ideas from participants and identifying both the parameters and possibilities of the technological landscape. The final stage of the project has been to identify further possibilities and to invite contributions from a wider audience, deepening collaboration through the use of social media and making software prototypes publicly available on the Reactive Colours website. This paper will focus on the significant contribution provided by collaborative partners and the subsequent analysis of experience.

**How Autistic Children Influenced the Project**

A critical research phase was undertaken before approaching collaborative partners in order to develop an informed understanding of the theoretical issues. Impairments in social communication, (Baron-Cohen, 1989; Frith, 1989; Wing, 1975) are considered to be the most significant behavioural characteristics evidenced in individuals on the autistic spectrum. There are many complex theories which provide explanations for this apparent lack of social functioning which may vary widely from severe to mild, however the issues are puzzling and for the purpose of this paper I summarise the ‘monotropism’ theory, (Lawson, Lesser, Murray, 2005), which has been most helpful in determining the context for the design of the Reactive Colours project.

Autistic people are understood to have monotropic interest systems, meaning that they are able to focus their attention intensely on a limited range of interests. In contrast, most non-autistic people have polytropic interest systems, meaning that they are able to divide their attention across many areas of interest and the focus of this attention is thus less intense, or ‘tunnelled’ (Lawson, Lesser, Murray, 2005). Intensity of focus can result in an apparent lack of interest in other people and may explain why autistic children may have difficulties with imaginary and social play, which require open-ness and flexibility of thought rather than a tightly focussed interest in the functional use of an object. In addition, autistic children characteristically have problems with the expression and interpretation of verbal and gestural language, which can lead to unwillingness to share experiences.

**The Significance of Play**

Play can be categorized in developmental terms under three broad headings (Piaget, 1971): firstly, functional or sensorimotor play requires the manipulation of objects; it is their visual and physical prop-
erties, which arouse interest. Secondly, in representational play the child begins to invent imaginary sequences and actions with the object of interest that correspond closely to real-life experiences. Thirdly, the child will direct interest to more symbolic forms of play and will create new meanings for the object and imagine a purpose other than one that directly relates to its function, for example, using a banana as telephone. For many autistic children the development of a capacity for using symbolic functions and the onset of representational play are severely delayed, instead they tend to prefer the functional approach; sensory-motor play of this kind, for example, banging, spinning and oral exploration, such as biting, is often repetitive and persistent and is notably non goal orientated and unusual (Leslie, 1987).

**Determining the Context**

The staff and children at one particular special school with an ASD support unit have participated throughout the design of the software and although other schools have since become involved, it has been the dedication and commitment of this core group that as made the most significant contribution to development of the project. Visits to classes, brief introductions to children and an audit of current educational technology followed before sketchbook ideas were shared and discussions on a potential design partnership were proposed. During this stage, the researcher gained valuable insight into teaching routines and the specific difficulties experienced by autistic children; teachers also enjoyed the opportunity to have input into the project.

What became clear from this early research was that the use of computers in schools tends to be limited to task-based activities that prompt functional interaction guided by specific educational objectives. Many software programmes adopt a heavily directed approach with explicit rules and highly organised structures, which are designed to specifically minimize the stress of uncertainty. However, the tasks tend to be inflexible, require minimal genuine interaction with others and therefore afford little creative and imaginative potential. This heavily guided structure may result in a child learning the rules rather than engaging in the joyful interaction that can occur when opportunities for discovery, surprise and curiosity are made available (Sherrat, 2002).

**Designing with Children and Teachers**

Simple storyboards, with no technical references other than anticipated mouse or keyboard activity, were prepared in drawing books, to quickly capture and represent ideas. The aim was to inspire teachers by showing mock-ups to help them envision possibilities beyond the confines of traditional interfaces. Prototype 'expressive' activities were developed and shown on a laptop computer to teaching and support staff, which prompted further feedback and suggestions.

Activities in the prototype varied from a blank screen of colour that changed in response to mouse action, to more complex keyboard activated screens that visually transformed and played a sound as keys were pressed. Visual tracking was exploited in a number of mouse-orientated activities. The cursor was the point of focus in the form of a shape that had the capacity to change in response to user action, in some cases leaving a trail, outwardly evidencing inner engagement. Sound effects and music were to provide feedback, for example the closer to the centre of the screen the louder the sound.

The systematic exploration observed in children interacting with the software suggested that whilst the actions were repetitive, a pattern of primary, secondary and tertiary circular actions was beginning to emerge, which matched those suggested in Piaget’s stages of sensorimotor play. Initially children would simply repeat their actions for their own intrinsic reinforcement value; however, as they became aware that their actions had some impact on the digital environment, they more purposefully pursued a response, having gained this they repeated their actions, with the obvious intention of achieving a self imposed goal.

As a result of these observations and with the encouragement of teachers, the designs for ReacTickles which followed incorporated a more sophisticated form of reactive cause and effect, designed to provide not only the reassurance of repetition (Winnicott, 1982), but also the opportunities to move from innate behaviours to more coordinated, confident and powerful responses.

Teachers and experts noted during their analysis of video footage, that some children were imitating the actions of others, particularly at the interactive whiteboard. Piaget’s reasoning that if behaviour is observed during a particular activity and mirrored after some time has passed then some symbolic encoding has occurred, reinforced the suggestion that while playing with ReacTickles, children were actually engaging in forms of symbolic play that are not evident in other more regimented digital environments.

**Implementation**

During the early design stages the team concentrated their efforts on creating as many variations of the reactive activities as possible, each variation incorporating the ideas of teachers and video analysis of children. The rapid 'suck it and see' approach en-
abled mistakes to be identified and designs to be quickly reconsidered. An evaluation of the ReacTickles software was undertaken using questionnaires and video footage. Children were given CDs of the software to take home and parents were invited to contribute with comments and suggestions. The purpose of this was to provide further insight and inspiration rather than a quantifiable method of surveying and data gathering. Design decisions were made on the basis of these observational techniques, and the structure and interface for ReacTickles began to take shape. What became evident from video analysis at this stage was that children, given the appropriate prompts from their teacher, were able to demonstrate certain characteristics associated with symbolic play. This was most significant whilst playing at the Smart™ Interactive Whiteboard, it was clear that children were attributing properties to actions in an imaginary way, for example, when filled circles ascend and wobble, a child enthusiastically says, “pop the bubble!” As another child voluntarily joins the activity, instructional vocabulary is shared between the two and the pretence continues.

A third child joins the group and extends the play; he imitates the actions of his peers and adds his own variations. In a different type of activity, where written words become the object of play, for example colour names form a wave and leave a trail, children voluntarily verbalised colour names, not simply as a descriptive label, but to draw attention to the action. Comments, such as, “I’ve made a circle!” clearly suggested that the child was inventing a context for the action and expressing a desire to share the experience with others.

**Expansion**

With participation in the project widening to a number of schools, the design team extended the research methods to invite contributions and feedback on the [www.reactivecolours.org](http://www.reactivecolours.org) website. Building from the methods and findings described above, the team proposed to extrapolate from some of the experience of open source software development, particularly its use of collaborative networks to iterate and improve software (Raymond E.S.1998). As with Lessig’s (2003) “innovation commons” and initiatives such as wikipedia (Stadler 2002) and ThinkCycle (Ridgway, L. 2002) the purpose of the online research has been to ensure an innovative, inclusive development model.

The informal and anecdotal comments shared through the web have introduced a level of participation that would be missed had the project solely relied on formal methods. Parents who witnessed positive reactions to the software from their children at home were able to express themselves instinctively, without the pressure or bias that can occur in formal settings.

The ReacTickles software is freely available on the site, thus the philosophy of, “release early and often and listen to your customers” (Raymond, 1998), which is fundamental to the open source movement, benefits the project by reaching audiences in their own private settings. For the young children who are extending their experience of using the software at school into the home, the website presents an opportunity to enrich the learning experience by enabling families to share activities that have been motivating for the child at school.

**Summative Evaluation of the ReacTickles Software**

As the designs develop, a more rigorous quantitative method of evaluation is taking place, using questionnaires with scalar choice responses. The primary goal of this evaluation has been to assess whether the task-free mode of interaction can provide a meaningful, engaging, exploratory environment for play, and whether increased confidence and self-esteem, can assist children in acting purposefully with others. Teachers discussed with the researcher aspects of the children’s experience that would be most appropriate to measure. Advice was also sought on standardised assessment procedures, however, whilst staff were familiar with these tools it was considered that none of them really worked for ReacTickles, as the purpose is to discover a child’s potential rather than gather typical data.

Therefore it was suggested that in order to determine whether or not the experience was meaningful, waiting and attending, would be useful to measure. In order to evaluate engagement and relaxation, concentration was measured, and in order to evaluate capacity for independent exploration and flexibility of thought, pointing and choosing were measured. Finally, the ability to act purposefully was considered by measuring mirroring and sharing.

The initial results of the formal data gathering process, using questionnaires with scalar choices, presented an interesting dilemma as a very clear pattern has emerged.

In a structured setting, with children using ReacTickles on the Smart™ Interactive Whiteboard, a group of six participants, aged five years, with severely delayed developmental ages (approximately one - two years) children evidenced good concentration skills and most were able to point and choose independently following prompts. Results evidenced that levels of attending and concentration were dramatically higher in these children for whom motivation and engagement in classroom settings is generally poor. However, waiting and turn-taking was
problematic and two of the children became upset at having to wait their turn. When the same group were introduced to ReacTickles a week later some improvement was noted and the teacher concerned has specifically requested that her study continues over more sustained periods. In free play sessions, where children selected ReacTickles as their choice of activity, the findings were similar as children showed excellent levels of concentration, with no need for additional prompts, but showed no desire to share. In a structured setting with six children aged five, who were developmentally more able and had already gained skills in waiting and turn-taking, the children were able to practice their skills independently and shared the experience enjoyably with others.

Teachers suggested that if the ReacTickles software was available to them as part of a structured learning session, where key elements of the curriculum could be addressed, it could be a highly rewarding, motivating resource.

As the evaluation continues, longitudinal data across more varied computer environments will be gathered, and will therefore be reported elsewhere.

In addition to user evaluation the ReacTickles software has undergone expert evaluation with ten other schools, the teachers participating have been enthusiastic and have provided the incentive to expand the project in the direction of developing a specific educational resource.

Conclusion

The methodology used during the creation of the ReacTickles project has highlighted the significant benefits of enrolling a dedicated and committed group around a model of research, inspire, listen and build. Children, teaching staff and experts in ICT, special needs education, adaptive and assistive technologies, psychology, media and graphic design have been extensively consulted during each phase of the project, even taking an active role in designing and producing documentation. Suggestions from teachers have been based on their thorough understanding of the children as individuals as well as their experience in educational practices and curriculum targets. However, they have not been constrained by the levels of attainment that dominate current thinking, and have been excited by watching children perform beyond expectation as they discover the delights of tangible technologies when the demands of pre-determined, point and click activities are removed.

As the project reaches the conclusion of its funded research phase, the possibilities for expansion have been clearly identified, most importantly, the future of the ReacTickles software will continue to meet the demands of potential audiences by pursuing democratic and flexible strategies for participatory design.

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About the Author

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A graduate of Graphic Design and Animation, I began my career on the popular children's TV series, SuperTed, before becoming a freelance animation producer researching and producing animation content for BBC One, HTV West and S4C. It was during this period that I began working with children as co-designers; the productions for which I was responsible pioneered the notion of children as creators of original programme content. A fascination for technology as an experiential medium has provided the motivation to undertake research at a high academic level, alongside teaching responsibilities. All my research has involved users directly, as well indirectly through web technologies. Reactive Colours© and ReacTckles© represent my most recent research activity which has been awarded funding from the NESTA Learning Programme. My responsibilities include research, project management and design. I have presented and published my work internationally, most recently I taught multimedia design at Sichuan Fine Art Institute and presented my research at Xi’an People’s Hospital in China. I am a member of the Higher Education Academy.
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