Tangible Technologies as Interactive Play Spaces for Children with Learning Difficulties: The Reactive Colours Project

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The positive role that technology can play in learning has been well researched and whilst there have been arguments raised by some that computer use, particularly with young children, may drain precious cognitive resources, there has been significant progress in the area of embodied tangible technologies. Drawing on this research and bringing together perspectives from human computer interaction (HCI), psychology, linguistics and graphic communication, I will present the findings of the Reactive Colours project, which has been (a) developing customizable sensory software, ReacTickles, and (b) investigating the impact of embodied user interfaces on social communication and learning for children with autism. Through my work I aim to demonstrate a democratic and participatory approach for the design of embodied user interfaces where manipulation is intuitive, and where expressive acts foster improvisation and provide an opportunity to encounter experiences independently of skill, knowledge or directed task. ReacTickles aim to subtly trigger collaboration between individuals and co-ordination through performative actions rather than the necessity to complete a directed activity. This novel approach allows the emergent idiosyncratic needs of the child to lead activities rather than the typically operational modes of traditional computer interaction. The significance of this for children with autism is that meaning is created and understood through sensory arousal and bodily action, rather than the necessity to interpret a graphically mediated environment. In this paper I will describe ways in which my research has been introduced in pilot studies in a number of schools throughout the UK and the impact partnerships with schools has had in developing ReacTickles and the emerging heuristics which may prove useful for all young learners, irrespective of individual developmental levels.

Keywords: Autism Spectrum Disorders, Tangible Technologies, Embodied User Interfaces, Manipulation, Improvisation, Performative Actions

Introduction

There is an increasing desire within school-based frameworks, to prepare children of all ages for the complex world of digital technologies. Even in the home, parents favour educational applications when selecting software for their children, which follows a general belief that children must be competent with technology in order to succeed in school and in the future workplace (Plowman & Stephen, 2003). In the UK, there is
widespread support for the use of Information Communication Technologies (ICT) as a means to improve the quality and standards of education and to assist teachers in the management of their daily teaching routines. Although positive motivational outcomes are frequently found when ICT is used to support engagement, research, writing and editing, and presentation of work (Passey and Rodgers, 2004), there is still little use made of sensory engagement, particularly, kinaesthetic, spatial/visual, interpersonal and intrapersonal, as a means to encourage collaborative learning, creativity and flexible thinking.

Most educational software is designed around a structure that tends to dictate a sequence of actions rather than allowing the child to initiate with his mind or body. Choice or options consist of selection from buttons or interface menus and task-driven activities tend to dominate the experience. The active areas of the screen are usually restricted to routine mouse clicks and key presses and sensorial interaction is limited to visual or aural feedback, rather than genuine sensory stimulation. When used in this way the computer takes responsibility for selective attention, meaning that children are not developing the ability to control their attention through planning and understanding the consequences of their actions (Healy, 1998).

The predictability and controllability of computers make them ideal environments for people with Autistic Spectrum Disorders (ASDs), who typically experience discomfort at unexpected change and the uncertainty of face-to-face communication (Jordan & Powell, 1990; Murray, 1997; Murray & Lawson, 2006). The testimonies of many autistic adults clearly evidence the use of technology for many highly creative and communicative purposes (Lawson, 2001; Grandin, 2000). The concerns within this study, however, have been with how the operational mode of computing can reinforce a mindset intent on finding one right answer leading to narrowness in thinking skills and imagination. Children with Autistic Spectrum Differences (ASDs) may be able to master their responses to a pre-programmed set of stimuli however, in this mode joint attention and spontaneous play skills are difficult to support as many social skill interventions do not offer reciprocity or child led initiations; instead they focus on discrete individual skills and inflexible modes of communication. These approaches that teach rigid behavioural routines do not appropriately reflect the unpredictability of typical human interaction.

Murray, Lesser and Lawson (2005) describe the autistic condition as 'monotropic', suggesting that in the competition between mental processes for scarce attention, monotropic individuals will have few interests that are highly aroused, as opposed to having many interests that are less highly aroused, which is the polytropic, non-autistic tendency. This issue of managing attention and how it impacts on children with ASDs has been of interest to the ReacTickles research and will be discussed within this
paper for its relevance to (1) social communication and joint attention; and (2) relaxation and task. Feedback from parents and teachers during preliminary interviews raised concerns at the intensity of focus children with ASDs demonstrated when engaging in computer programmes - they were described as becoming 'locked in' and impenetrable, often unable to tolerate the presence of another or to co-operate in other activities, suggesting that their interests were highly aroused and their attention focussed deeply on the task.

In this context, when computers are predominantly employed to assist in analytical tasks, they are rarely used to support mutual awareness and improvisation. Through the discussion and analysis of the ReacTickles software, presented in this paper, I will demonstrate a much wider range of experiences and possibilities afforded by computers when the emphasis shifts from operational routines to a computationally enhanced landscape for performative acts of personal expression.

ReacTickles are embodied user interfaces that use physical manipulation and perception to encourage playful exploration and collaboration in a variety of technological settings, they do not require specialist equipment or training as they utilize existing equipment in homes and classrooms to support different sensory modalities. The natural bodily interactions afforded by the attributes of the technologies, for example mouse, keyboard, touch-screen, interactive whiteboard or microphone, are at the core of how ReacTickles work. ReacTickles do not function unless they are played with through touch or sound; for the player, this multimodal interaction offers a dynamic experience that is predictable, but it is also infinitely variable, as each encounter encourages further improvisation, allowing the user to more flexibly determine the sequence of actions, an approach which is far more closely aligned to natural human behaviours (Dourish, 2001).

Play and Learning with Computers

Many of the skills children need in their development as social beings, for example turn-taking, decision making, language skills, monitoring and reciprocity, evolve naturally through play. Piaget (1945/1962), in his studies of child development, argued that children actively acquire knowledge through interacting with their physical surroundings, and the process of interpretation, which occurs as a child actively investigates his environment, is the precursor to imagination and abstract thought. Many psychologists and philosophers agree that a child’s developing mental capacities emerge in the context of social interaction, and as the child progresses from perception of the physical properties of objects to theorising about them, they are drawing on generally developing capacities for causal understanding (Elian, 2005). When two individuals co-ordinate and interact with an object or event, they begin to acquire joint
attention skills (Tomasello, 1995). Joint attention encompasses a range of behaviors, including gaze following, social referencing, shared engagement and imitation. As children develop these skills they will increasingly use eye gaze and gestures such as pointing, rather than screaming or challenging behaviors, to draw attention to their needs and demonstrate a desire to participate in a social world.

Play has also been shown to reduce stress and to enhance creative and imaginative thinking; children learn best when they are given the opportunity to construct knowledge without direct instruction, when they are give full control in an open-ended play environment (Papert, 1972 & 1977). Papert’s book, Mindstorms (1980), set the foundation for the generation of educational technologists who have been profoundly influenced by his ideas on the computer as a “transitional object” and its role as a cognitive bridge. Although there are clearly alliances with the work of child psychologist D.W. Winnicott (1982), who presented the emotional relationship between inanimate objects as a substitute for the presence of the mother, Papert’s theory draws on the affective role the transitional object has in children’s learning and therefore, is more relevant in the context of this work and children with ASDs.

For the purposes of this study our interest is in the play routines of typically developing young children, chronologically aged between four and seven years, and those of children of a similar developmental age with a diagnosis of autism (Kanner, 1943). It is at this age that children begin to use their imagination and to practice managing behaviour, they are able to keep concentrating when something distracts them or their interest fades, and use language to draw attention to their actions; they are able to complete tasks without continuous reminders and they to show empathy and understanding towards others (Healy 1998). For young children with ASDs, this natural development is likely to be delayed. Although they vary individually in terms of the severity of their autism and intellectual ability, children with ASDs will generally experience difficulties in non-verbal and verbal communication, the ability to understand social behaviour, and the ability to think and behave flexibly. (Wing, 1998)

The apparent lack of flexibility of thought can be observed in the unconventional play activities of young autistic children. Whilst their play patterns will vary widely, many children will engage in repetitive actions and may show an unusual or obsessive interest in the function of an object rather than engage in more imaginative, pretence and social activities (Leslie, 1987; Seigal, 1996). Many children with ASDs many not understand social cues and therefore may not seek social stimuli in their interaction with others, suggesting a preference for solitary play (Sherrrat,
1999 & 2002; Jordan & Libby 1997; Seigal, 1996; Beyer & Gammeltoft, 2000). As a result joint attention, which arises when two individuals mutually attend to and share an interest, can be a difficult concept for many young children with ASDs.

**Embodied Play**

As the technological parameters for information, education and entertainment have merged, and with the most recent developments in tangible, or touch-activated interfaces, the distinction between digital and embodied play is weakened and the opportunities to use pointing as a joint frame of reference increase. Interactive whiteboard screens, plasma screens and even a touch screen monitor can afford manipulations that present an opportunity for more embodied forms of interaction. Traditional Graphical User Interfaces (GUIs) rely on the interpretation of symbols to construct meaning, which in turn will lead to a digitally represented task; the typical process is to manipulate the environment with a physical object that has no specific behavioural or representational meaning (Fishkin, 2004). An example of this would be pressing a key or moving a mouse to perform many functions, all of which will have a different output, for example, menus, buttons, folders, and controllers (Ishii & Ullmer, 1997). Embodied tangible technologies enable a close relationship between manipulation through input and perception through output. One function is generally assigned to one action, the focus is on direct perception rather than the semiotics of form. A more embodied experience results as the user can focus on the impact of their action rather than the tools that control it (Dourish, 2001; Fishkin et al, 2000).

1. **Embodied Interaction**

The most profound learning experiences involve embodiment, live experiences and interactions between people and the world they inhabit. More than seventy per cent of learning experiences are accidental or informal (Thackara, 2005), and occur during face to face communication as our body acts as a medium that transforms our internal emotions and intentions into external signals actions, expressions, gestures movement and so on. Direct contact with the environment that surrounds us is critical to learning. Touching and various forms of manual investigation influence brain function, even language and culture (Singer, 2006), for the young child, movement and physical activities provide the foundation for higher-level cognition through the integration of the brain’s sensory association areas (Healy, 1998). Cognitive forms of intelligence, such as language, as well as certain visual-spatial skills, are all learned from using the body to
perform movements in sequence and by navigating the body through space. The child’s muscles register the spatial organisation of the environment, which provides the foundation for higher conceptual understandings, such as proportion and velocity.

Embodied user interfaces attempt to make interaction with technology more like everyday actions, which are continuously improvised and adapted in response to unpredictable forces, and where interactions are rarely stable objective phenomena. In the real-world actions are organised in response to the setting in which they arise and as a result form part of an ongoing improvised activity, (Suchman, 1987). Therefore the notion of embodiment is not simply about experiences that we encounter directly through actions in the physical world, it also encompasses the notion that real-world experiences include phenomena that unfold directly in shared actions and conversations (Merleau-Ponty, 1962).

**Description of ReacTickles**

The preference that young children with ASDs demonstrate for physical, sensory and manipulative play has been very influential on the design of ReacTickles and reported widely in previous work (Keay-Bright, 2006 & 2007). In this study the interest is in the manipulative potential of embodied user interfaces to enhance social interaction by providing a safe place for mutual awareness, which can be demonstrated through actions such as pointing and gesture.

ReacTickles consists of a simple cyclic interface - a clock - when the numbers of the clock are touched or the corresponding number key pressed the player is immediately linked to a ReacTickle game (see figure 1). The games are played using any standard input device and well as touch screens, switches and joysticks. Some of the games will be generic to all input modes, although they will respond differently, according to the actions afforded by the device; others will be specific to the particular mode of input. The games take the primitive actions associated with familiar objects or phenomena, such as squeezing bubblewrap, popping bubbles, twanging elastic and flicking paint and combine them with more complex patterns which endow these activities with the potential for symbolic meaning (Keay-Bright, 2007). At any time during play, the player can return to the clock, choose a new game or input mode, or even change the colour palette, speed of performance and volume of sound. Whilst this facility to personalise the game is an essential aspect of improvisation and experimentation for any individual, it is of particular significance to the child with ASD, for whom sensory differences may
result in exclusion from activities that arouse the sensory system as the coping mechanisms that arise from this can be disturbing for others.

Figure 1: The clock interface

**Rationale for the Design**

The ReacTickles environment aims to consistently elicit positive user experiences by reducing the cognitive burden of computer-mediated overload (Weiser & Seely Brown, 1996). By engaging the senses, particularly the kinesthetic sense (the sensory awareness of the position and movement of the body), and removing the necessity to conform to the demands of a task, ReacTickles foster a more natural flow of interaction between the user and the interface. Thus the availability of attention may be widened, making the experience cognitively less demanding and more ambient, playful and relaxing than more traditional software interfaces. In the book, The Coming of Age of Calm Technology (1996), Weiser and Seely Brown suggest that to promote relaxation, the user must be able to shift attention back and forth between what is of explicit interest and what may be occurring on the periphery of attention. The authors imply that by placing things in the periphery, a more natural relationship between an object in the world and the intention, perceptions and capabilities of the user is afforded.

This concept of affordances (Norman, 1988 & 1990; Gibson, 1979), which encourage a tight coupling between the environment and a range of possible actions, encountered directly rather than abstractly, are strong feature of ReacTickles. Dourish (2001) describes this coupling of activity and environment as central to embodied interaction, as the source of meaning is found through actions and the possibility for actions, rather than though a cognitive process requiring the interpretation of graphically mediated symbols. To illustrate this concept, when playing with ReacTickles using a mouse a range of spatial smoothing, circling and
dragging movements are afforded; the keyboard activities promote tapping, pressing, and repetition, which elicit locational responses on the screen that match the spatial organisation of the keys on the keyboard; using the microphone will create a response depending on the volume of sound created by the user, either through the voice or some other instrument. When ReacTickles are played on an interactive whiteboard, gesture and pointing are employed both to manipulate the interface and to draw attention to the actions, gross motor movements such as stretching and jumping become key actions in the experience as fine motor demands are reduced (Figure 2).

![Figure 2 Stretching and Pointing](image)

The point of focus for the interaction is an important feature of ReacTickles and represents a significant difference to the way attention is managed when operating a computer. Traditional interfaces tend to have a single or limited number of areas on which to focus, defined by the position of the cursor or the active window (Thackara, 2005). When inside a ReacTickles game, the cursor disappears, allowing the player to focus attention on their actions using the entirety of the screen, selecting from deep focus to peripheral focus as required. For example, popping a bubble will cause a number of new bubbles to appear, the player may choose to reach for a more challenging bubble to pop on another part of the screen, or to wait while a seemingly endless array of bubbles afford a range new possibilities as they float and wobble spontaneously on the screen, changing scale and popping themselves as they collide. The cursor remains invisible until the player returns to the clock. As no cursor resides on the screen to prompt action progress is directed by the player through exploration, or another player should he be invited to join the game.

The value of this approach is that it shifts the focus away from the functional demands of the technology towards encouraging users to explore, create and communicate through the actions they perform. Social
interaction is supported through different forms of activity rather than being limited to the confines of the interface. Actions such as pointing and turn-taking can occur through the technology rather than enforced in a heavily structured sequence of interface actions.

Methods

As Suchman’s work on “situated actions” states, human activity does not correspond to a sequence of formulated plans; our interactions with the real-world are active interpretations formed in response to the features of the setting in which they arise. This model of behaviour as an ongoing improvised activity was very influential determining the design methodology for ReacTickles, and is of particular interest in the desire to offer experiences that are transferable across a variety of settings - an important factor in promoting generalisation and reducing reliance on learnt cues and stimuli. The complexity and range of differences between children on the spectrum can be extreme, so observational and qualitative, as opposed to purely empirical design methods, were to provide the greatest opportunity to discover how children would perform with the software and how their particular interests could be encouraged, supported, maintained and made visible through their interactions. In order to develop a design approach that is conscious and considerate of the young target audience, collaboration and consultation at all levels of the design process had to be implemented. Druin’s (1999) contextual research studies that involve children as co-designers provided the basis for the design research methodology which centred around participation with children and teachers from a specialist ASD Unit in a school in South Wales UK.

The relationship was initiated by a series of preliminary activities in which teachers were encouraged to integrate simple prototypes into a regular teaching day; they were given complete autonomy to decide when and how they would use the samples. Formal evaluations were avoided in favour of more a speculative and qualitative assessment of interest. These methods allowed the idiosyncratic behaviours of the children to present themselves naturally as they explored the software under the expert guidance of their teachers. Each iteration of the ReacTickles software consisted of short feedback loops, with regular reflection and evaluation which aimed to ensure that the role of *key informant* (Druin, 1999), played by the children and teachers, was understood and valued.

Traditional forms of evaluation normally concentrate upon the ability of the user to perform a series of actions within the options offered by the computer, however, for ReacTickles, these metrics were ultimately only
helpful when used in conjunction with other qualitative methods. Whereas usability is conventionally tied (1) to the capacity of the interface to undertake one particular, pre-defined action, and (2) to the user’s understanding and completion of the pre-defined action, ReacTickles in contrast makes available (a) a network of possible actions enabled by the user’s open, playful interaction, and these are evaluated (b) as a range of actions which are performed and invented rather than having to be understood and completed. Thus the primary interest in evaluation was to detect how and where in the experience children were being most playful, and how play and the reduction of anxiety can support and encourage socially motivated behaviours such as pointing and turn-taking. Ease of use, however, was fundamentally important to teachers as a breakdown or lack of response from the system could result in an interruption in the flow of activity or fears that children could become upset by unpredictable or inappropriate responses. Regular interviews and video analysis of children as they encountered the software in their natural settings demonstrated that teachers were actually finding imaginative ways to experiment with the software in both structured and free-play sessions. Although an inherently time-consuming process, a sense of trust and ownership emerged which enabled to project to evolve organically as part of teaching routines.

Pilot Studies Evidencing Enhanced Bodily Awareness

A number of studies have been conducted throughout the project, (Keay-Bright 2006 & 2007). The paper will concentrate on two studies which considered whether the ReacTickles embodied user interface could provide a useful and effective classroom tool to increase motivation, confidence, imagination and sociability for children with ASDs in a different classroom settings.

Study One - Keyboard ReacTickles

The group in this study attended a Community Special school in London, UK that had pupils with autism spectrum disorders and other low incidence special educational needs. The children were chronologically aged 11-19 years and had poor receptive and expressive communication. Good use of technology is made across the school, though teaching staff advised that it could be difficult to motivate and engage those pupils with a dual diagnosis of severe learning disabilities and autism.

A consultant researcher with expertise in the use of ICT for pupils with learning difficulties conducted the study and the input device chosen was the keyboard. The sample group comprised of three pupils (one female, two males) with ICT skills at P6 of the National Curriculum Performance Levels, meaning they could respond to simple instructions and use the
computer for specific tasks with support. None of the children were able to use the keyboard in terms of letter recognition, but all had the manual dexterity to press and hold individual keys. Most of their speech was echolalic, repetitive or unrelated to the task being undertaken. All the children could follow three word instructions so directive speech was kept very short and simple to ensure they understood each activity.

The coding categories used in the study were adapted from the measurement scales of Aldred, Green and Adams (2004) and the observational checklist of Cumine, Leach and Stevenson (2000).

- Behaviour – was the child interacting physically, verbally or attending to the activity using only eye contact?
- Operating – which key or keys was the child pressing or holding down? It was decided in advance that approximations to key presses would not be recorded, only those achieved.
- Creativity – would the child only press keys that they were directed to, or would they imitate, or would they try new key presses by exploring the keyboard themselves?
- Social – were there instances of shared attention, turn taking or communicating their experiences to others present? This included sharing the focus of the activity by looking, showing/pointing or body orientation.

The findings of this study were very encouraging and showed small yet significant progress for each participant. For all three there was a noticeable increase in confidence, displayed in choice making, touching previously unexplored areas of the keyboard and learning that holding down keys gave them different, often longer lasting results than simply pushing a key and letting go. It was reported each child in the study wanted to touch different areas of the keyboard and moved from pressing individual keys to trying out the idea of holding down a key whilst concentrating on the effect this created on screen. One of the most exciting observations was the way in which both the participants and their support staff found new ways to approach the keyboard, simply to play. The children were very enthusiastic and rapidly learned to operate the interface, which was considered to be a rare occurrence for this group. The researcher reported that the software could easily be integrated as a regular part of the curriculum, which was a welcome change from seeing software used in isolation, as a specific component of a literacy lesson, or as a behavioural reward.
6.2 Study Two - Interactive Whiteboard ReacTickles

Another study, using questionnaires with scalar choice responses as well as interviews and video analysis involved participants from schools throughout the UK, recruited through conference presentations, school networks and the community of interested teachers and parents fostered through the reactivecolours.org website (Keay-Bright 2006 & 2007). The format for the study was adapted from social skills checklists - Kathleen Quill’s Do-Watch-Listen-Say: Social and Communication Intervention for Children With Autism (Quill, 2000) and Autism in the Early Years Observation Profile, (Cumine, Leach and Stevenson, 2000), with additional expert guidance from the University of Birmingham, UK, School of Education. The study was conducted in a variety of settings, monitored over three sessions at intervals of approximately one week. For the purposes of this paper I will summarise the feedback given on activities that took place using a Smart® Interactive Whiteboard. Smartboards® enable children to control their experience through the touch of their fingers. When used in this way ReacTickles become interactive surfaces, which render visible the outward response to being touched or stroked visible through a corresponding movement, shape morph or colour change (Figure 3).

Figure 3 Smoothing and Circling

What became evident from video analysis of the different groups using ReacTickles on the interactive whiteboard was that children were using their physical and perceptual skills in a manner that was natural for them, and that they were able to use pointing and gesture to demonstrate their interest and to invite the participation of others. Gross motor activities such as stretching, jumping, reaching and smoothing became part of the embodied experience, together with fine motor skills such as circling, tapping and pointing, all of which had a direct relationship to the digital response on the Smartboard™ surface. One child expressed discomfort at the start of the session; he was observed running backwards and forwards.
flapping his hands violently, however, following encouragement from his teacher, he began to engage with ReacTickles, and within minutes started smoothing the Smartboard™ as he and became calmer and in control of his actions. Two classes using the software had no verbal language and had difficulties with concentration. Teachers noticed that when these children were playing with ReacTickles at the interactive whiteboard the levels of concentration improved, as they were able to see their actions mirrored on the screen. It was also noted that expressive communication also improved, as the children were able to demonstrate their interest through actions.

A different group, who were able to use verbal language, demonstrated certain characteristics associated with symbolic play. They attributed properties to actions in an imaginary way. For example, when filled circles ascend and wobble, a child enthusiastically points and says, “Pop the bubble!” Another child voluntarily joins the activity and shares instructional vocabulary as the pretence continues. A third child joins the group and extends play, imitating the actions of his peers and adding his own variations. In a different type of activity, where 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.

Findings from questionnaires (Figure 4) suggested that levels of attending and concentration were dramatically higher for most of the children for whom motivation and engagement in classroom settings is generally poor. Most children were able to wait and watch another child play although some found waiting problematic and one child was reported to become anxious and upset at having to wait. Results for turn taking were inconclusive; the reason being that many of the children were playing on their own or the teacher was not able to introduce turn-taking routines into the sessions. The assessment of mirroring, showed similar responses as when there was no other child present it was difficult to monitor, however the majority of responses indicated that the child copied the action of the teacher, and demonstrated an improvement over the three sessions, particularly with complex actions, such as pushing, popping, pulling, controlling speed. The facility to choose has been a very successful feature of the project; the additional comments provided by staff indicated that most children enjoyed the clock interface and were able to freely make choices without the need of assistance once the rules had been demonstrated and understood. Many of the children required very little prompting, which indicated increased confidence and motivation. Of
the responses to questions on imaginative thinking, most indicated that children were able to move from simple repetitive actions, to more purposeful ones where, smoothing, circling and dragging could be extended and pointing, gestural and verbal responses were employed to direct attention to the action.

Figure 4 Analysis of Data

Conclusion

The challenge for the Reactive Colours project was to create playful experiences that could engage through experimentation with bodily sensations and interests in a manner that is both direct and personal. For this existential medium to be of any value it had to be motivating, relaxing and demonstrate potential for social interaction which is a prerequisite for learning in young children. As Powell and Jordan state, a common goal in approaches to learning for children is that it “…can be greatly enhanced if the tasks chosen are highly motivating for both staff and pupils and if they can be enjoyed together. That seems to be the real therapeutic context in which children can experience the sharing of emotions that has not occurred naturally and spontaneously in the course of early development”
(Powell & Jordan, 1997, p167). From the studies conducted during the development of the ReacTickles software it became evident that children were able to play, explore and share without discomfort. For these children, there was perceived value in extending the use of computers, widely acknowledged as a beneficial environment for learning and communication, to provide a stimulating starting point for bodily exploration and the outward representation of interests that might otherwise not be expressed. In this wider context, manipulation, performance and improvisation, typical actions in everyday life, could occur comfortably in the computationally mediated environment. The ultimate goal of finding a sustainable, scalable and transferable way to integrate the ReacTickles experience into busy teaching routines, was addressed in the latter stages of the work and was realised though the enthusiasm and support of dedicated teaching staff and lecturers at Birmingham University, School of Education. This work will be reported elsewhere.

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References


**Related Links**


National Curriculum guidelines for Social Skills for pupils with Learning Difficulties: http://www.nc.uk.net/ld/PSHE_content.html

National Curriculum guidelines for ICT: http://www.nc.uk.net/ld/ICT_perf.html - 2

Smart Technologies: http://smarttech.com/

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