Computers & Education 63 (2013) 17–27

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Additional key factors mediating the use of a mobile technology tool designed to develop social and life skills in children with Autism Spectrum Disorders: Evaluation of the 2nd HANDS prototype

Joseph Mintz*,[1]

Faculty of Children and Learning, Institute of Education, University of London, 20 Bedford Way, London WC1H 0LH, UK

ARTICLE INFO

Article history:
Received 12 January 2012
Received in revised form
2 November 2012
Accepted 6 November 2012

Keywords:
Pedagogical issues
Secondary education
Computer mediated communication
Autistic spectrum disorders

ABSTRACT

Of late there has been growing interest in the potential of technology to support children with Autism Spectrum Disorders (ASD) with social and life skills. There has also been a burgeoning interest in the potential use of mobile technology in the classroom and in the use of such technology to support children with ASD. Building on these developments, the HANDS project has developed a mobile cognitive support application for smartphones, based on the principles of persuasive technology design, which supports children with ASD with social and life skills functioning – areas of ability which tend to be impaired in this population. Based on the evaluation of the implementation of an initial prototype, a second prototype was developed in the summer of 2010 and implemented in the 2010/11 academic year in four special schools for children with ASD. This paper reports on a qualitative interpretivist evaluation of the second prototype, identifying which factors mediate the level of engagement with the technology by both teachers and children. Fifteen teachers and twenty six children used the second prototype.

Data was gathered using from teachers ($n = 15$) using direct classroom observation, individual semi-structured interviews, and questionnaires. Semi-structured interviews were also used to collect data from some parents ($n = 6$) and children ($n = 10$). A number of factors identified in the first prototype are also found to be present in the second prototype. However new factors are also identified, including student awareness of difficulties and associated motivation to change, and the preference of some children with ASD to receive persuasive messages from mobile devices. Particular issues related to the cognitive structure of children with ASD are considered. Further design guidelines are proposed for future implementations of similarly purposed technology tools.

1. Introduction

Recent developments in mobile applications for children with ASDs have shown mobile ICT's potential to enhance participation in educational settings and wider social contexts, for young people with the social, emotional and cognitive impairments typically associated with this condition. Some of this work has been done as part of the HANDS Project (HANDS Project, 2011).

ASDs are developmental disorders, whose aetiology has a significant genetic component, arising in early childhood, and result in a lifelong condition (Volkmar, Lord, Bailey, Schultz & Klin, 2004). Wing and Gould (1979) classify the main behavioural expressions associated with ASD as the "autism triad". These are mild to severe impairments in (1) reciprocal social engagement, (2) reciprocal communication, and (3) flexible regulation of self, behaviour and interest.

Impairments in social and communicative reciprocity and in adaptive, flexible regulation of self and behaviours in individuals with ASD lead to significant difficulties in both social and life skills (Howlin, 2004). Having ASD, consequentially, leads to a very high risk of marginalization and social exclusion, with adolescence and early adulthood being especially critical periods for individuals with ASD. They

* Tel.: + 44 02076126382; fax: + 44 02076126177.
E-mail address: j.mintz@ioe.ac.uk.
[1] Formerly at London South Bank University, UK.

0360-1315/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.compedu.2012.11.006

have a highly decreased chance of finding adequate jobs (and jobs at all), of managing an independent life, and of establishing long-term interpersonal relationships (Haskins & Silva, 2006; Shea & Mesibov, 2005).

Given the high risk of marginalization and social exclusion associated with ASD, it is not surprising that there has been some hope invested in the potential of assistive technology to support individuals with ASD in overcoming such barriers to adaptive functioning and social interaction.

Bernard-Opitz, Sriram, and Nakhoda-Sapuan (2001) used a multimedia computer program to teach young children with ASD how to think through social situations and conflicts whilst Parsons, Mitchell, and Leonard (2004) and Mitchell, Parsons, and Leonard (2007) evaluated the potential of virtual environments to teach both social awareness and social behaviours to individuals with ASD. Wallace et al. (2010) demonstrated that young people with ASD find modern virtual reality settings authentic enough to allow for realistic simulation of social situations with associated potential for development in social skills. The Aurora project (Aurora, 2000) and studies by Dautenhahan and Werry (2004) explored the use of robotic technology in developing social interactions. In related work, Farr, Yuill & Raffle (2010) reported on an exploratory demonstration of the successful use of technology embedded in graspable toys to promote play and increased social interaction.

In a recent review, Wainer and Ingersoll (2010) examined fourteen studies going back to 1995, which used innovative multimedia programs to teach language, emotion recognition or social skills to individuals with ASD. Their review indicated that some studies indicate a likely potential for the use of technology to deliver positive interventions in social and emotional development (see Moore & Taylor, 2000; Rayner, Denholm, & Sigafoos, 2009).

There has also been growing interest in the last five to seven years in the use of mobile technology with children with ASD. Mechling, Gast, and Seid (2009), in an exploratory study, evaluated the use of a Personal Digital Assistant (PDA) with multiple prompt levels, reporting on its potential to increase efficacy in completion of novel tasks and transitioning within and between tasks. Gentry, Wallace, Kvarfordt, and Lynch (2010) used standardized measurement tools to measure the efficacy of PDAs as cognitive aids in a sample of high school students with ASD, indicating positive initial outcomes. Reports are also being published on the use of mobile technology specifically to support social skills development. Tentori and Hayes (2010) report on the initial implementation of a smartphone application designed to give children social cues in specific social situations.

This paper reports on the implementation of the second prototype of a smartphone application developed in the HANDS project, which allows teachers to flexibly develop individually tailored interventions to develop social and life skills. The key objective of the paper is to report on an interpretivist evaluation of the implementation and use of the second prototype, identifying key factors mediating the level of engagement with the technology by both children and teachers, taking such engagement to be at least indicative of the likely effectiveness of the technology in bringing about positive behaviour change in the domains and social and life skills. Particular emphasis is paid to novel mediating factors identified in the evaluation of the second prototype which were either absent or only weakly detected in the evaluation of the first prototype (Mintz, Branch, March, & Lerman, 2012).

1.1. Mobile systems for people with cognitive disabilities

There has been a parallel interest in the use of mobile technology to support people with cognitive disabilities due to traumatic brain injury, stroke or Alzheimer's disease, particularly in respect of providing support for travelling. The MAPS-Lifeline prototype (Carmien, 2004; Carmien et al., 2005) created a GPS-based mobile device system, which included dynamic monitoring by caregivers. Lindström (2007) reports on Swedish trials of navigation assistance systems based on mobile technology and GPS for people with cognitive disabilities. User reports indicated that reliability and ease of use were design priorities. The Opportunity Knocks project (Patterson et al., 2004) created a mobile GPS-based application to provide cognitive assistance to users with cognitive impairments using public transport. The system automatically detected the user's current mode of transportation, and using a heuristic learning algorithm, detected when the user does something unexpected such as missing their usual train station. Brown et al. (2011) report on their development and evaluation of an initial prototype of a GPS-based Android application to support route navigation based on serious gaming. Users with intellectual disabilities and sensory impairments rehearsed potential routes using the application games, potentially reducing reliance on the need for guidance and support during travel.

1.2. The HANDS project

The HANDS software consists of a web based flexible toolkit that teachers use to develop specific support and intervention sequences specific to the need of each child. These sequences consist of a series of linked screens, each of which can include customizable text, images, video and sound. These customized "Personal Trainer" sequences can be linked to the associated comprehensive diary function also included in the software. Personal Trainer sequences can be stored as templates, and a sharing function allows teachers to adapt existing sequences for other children.

Intervention sequences developed using the flexible toolkit (see Fig. 1) are then loaded via a synchronization function on to the client application on the child's smartphone (see Fig. 2). On a regular basis the teachers then encouraged children to complete both the life skill and social skill task using the support of the intervention on the HANDS application.

The system also includes an electronic footprint feature that creates a log file record for every use of the mobile application by the child. The application was developed using Windows Dynamic Mobile and smartphones used included the HTC Diamond and HTC Touch HD. A pilot implementation in Android 2.2 was also undertaken.

HANDS was developed using the principles of Persuasive Technology Design (Fogg, 2003), a sub-discipline within the broader field of human–computer interaction. A growing number of researchers and systems designers in the last five years (see Ploug, Hasle, & Oinas-Kukkonen, 2010), responding to developments in this sub-discipline, have shown an increasing interest in how computers can be consciously designed to persuade users towards a particular course of action. The majority of applications to date have been developed for commercial contexts. For example, aspects of persuasive technology design are incorporated in to many website applications. The well known Ebay site uses a rating system to indicate buyer and seller feedback – a coloured star and a number is placed next to the users' names to indicate different levels of feedback. The intent of the designers in implementing this is to persuade users to be fair and honest in their transactions on the site. HANDS was one of the first projects to apply Persuasive Technology Design for use in educational settings.

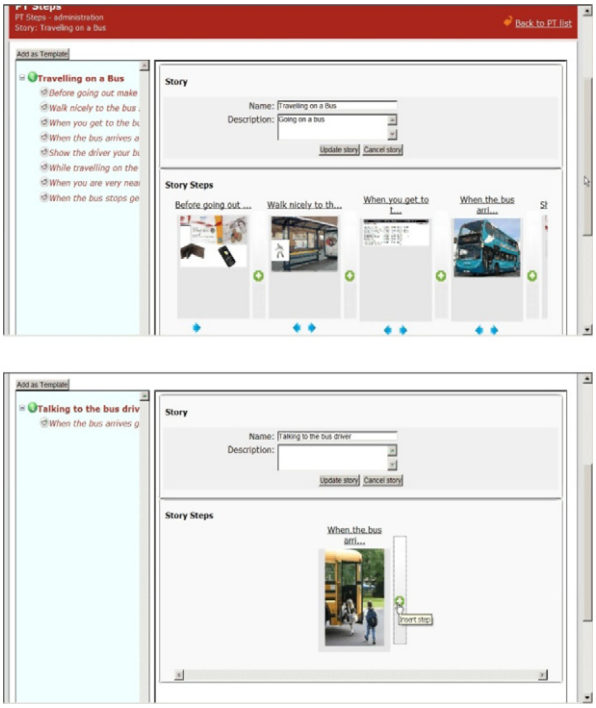

Fig. 1. The HANDS server based teacher set up function showing creation of step-bystep sequence for "getting the bus independently".

In HANDs we highlighted the concept of Kairos, which in persuasive design refers to leveraging particular opportunities when users of a system are more likely to be receptive to persuasive messages designed to bring about behaviour change. In other words, messages are more likely to be persuasive if they are delivered at the right time and place. Fogg considers Kairos as being particularly relevant for mobile persuasive systems (Fogg, 2003, Fogg & Eckles, 2007). He argues that as mobile phones, integrated with social networking technology, become more and more a central part of the lives of young people, particularly those in the 11–21 age range, mobile technology offers opportunities for interventions to be delivered at a time and place when the young person is receptive to receiving them.

Implementation of the initial prototype of HANDS took place at four special schools for children with ASD (in the age range 11–16) located in Denmark, Sweden, Hungary and the UK in 2009–2010. A qualitative interpretivist evaluation was undertaken using direct classroom observation and individual semi-structured interviews with teachers, parents and children. The results of the evaluation of this initial prototype were reported on in Mintz et al. (2012). The evaluation indicated that a number of key mediating factors – user attachment, Kairos and teacher source credibility, were significant in determining levels of user engagement.

Meschtscherjakov (2009) specifies that user attachment "signifies that mobile devices can act as an expression of an individual's personality or a symbol for group membership, and as such act as an extension of or form part of an individual's sense of identity". Fogg proposes that the effectiveness of specific behavioural change messages delivered via mobile devices is enhanced when there are ongoing repeated positive interactions with a range of cognitive and social functions on the device (Fogg, 2003; Fogg & Eckles, 2007). The evaluation of the initial HANDS prototype demonstrated a number of cases in which there was a correlation between repeated positive interaction with other phone functions (including SMS text, YouTube and social networking sites, camera and video) and response to specific behavioural modification messages from the HANDS software.

The evaluation of the first HANDS prototype indicated that in a number of cases Kairos was closely linked with home-school collaboration. In cases where teachers worked closely with parents, the opportunities for behavioural messages to be delivered in the home setting, which in many cases was the "right place", was increased.

In a number of studies, perceived teacher credibility has been shown to be a potential factor in student behavioural and academic outcomes (see Amber et al., 2009; Jason & Herring, 2005; Thweatt & McCroskey, 1998). In the implementation of the first HANDS prototype, there were a number of instances were teacher source credibility was successfully used to increase the force of persuasive behavioural messages delivered by HANDS. For example, in some cases a video of the teacher giving instructions was loaded on to the client mobile application.

Based on the qualitative evaluation of the first prototype (Mintz et al., 2012), a number of improvements were introduced in to both the design and implementation procedure for the second HANDS prototype ("Prototype 2"), which was developed in the summer of 2010. These improvements included a more intuitive and less cluttered graphical user interface. Further, due to more extended beta testing with teachers before the application was released to the children for use, there was also a significantly higher degree of technical stability. Based on the pooling and sharing of the teachers' experience of using Prototype 1, there was also an improved online guidance system which included pedagogic case studies based on instances of successful use, and a shareable image library. Sharing of the ongoing development of best practice use between teachers was also facilitated by regular online meetings where experiences with individual children were shared. Teachers were asked to make use of the best practice examples derived from the experience in Prototype 1 and to choose a relevant life skill related situation and social skill related situation that proved to be difficult for the child. For example, for one child the life skill task was getting on the bus independently and the social skill task was to use the telephone and pass on a message to their teacher. Teachers took the primary responsibility for designing interventions to support life or social skill functioning in the context of these situations.

Fig. 2. The HANDS smartphone client application.

The second prototype was implemented and evaluated with another sample of fifteen teachers and 26 children at the same four special schools from October 2010 to July 2011.

1.3. Persuasive technology design and motivation

Persuasive Technology Design assumes that the target user of the technology has (or has the potential to have) motivation to achieve a goal or behavioural change (Fogg, 2003; Fogg, Cuellar, & Danielson, 2008). Although Fogg (Fogg et al., 2008, p. 137) does not rely purely on one particular theory of motivation, he does make extensive use of Bandura's theory of self-efficacy (Bandura, 1977). Bandura uses a model of emergent interactive agency (Bandura, 1986, 1991) that implies a significant degree of autonomous goal setting by the individual. The idea that individuals have, even within limitations set by external environmental factors, the agency to set goals or desired behaviour changes for themselves, is at the heart of Fogg's proposition for persuasive technology. This is clear from his extensive discussion about ethics (see Fogg, 2002; Fogg, 2003; Fogg et al., 2008) where he places a strong emphasis on persuasive technology promoting self-determination – that is persuading users, not manipulating or coercing them. However, in doing so, Fogg does not remove the distinction between intrinsic and extrinsic motivators such as classroom rewards. Rather, in line with recent developments in humanistic motivation theory such as Self Determination Theory (Deci & Ryan, 2008), Fogg considers that extrinsic motivation can only be regarded as ethical and effective when an individual has identified with the values associated with a goal and integrated it in to their sense of self.

1.4. Cognitive structure in ASD

Persuasive technology design has been formulated with regards to typically developing participants. It is important to consider to what extent young people with ASD have a motivational structure which is at variance with the assumptions made in persuasive design. Cognitive variations in ASD include impairment in executive function, which is the ability to maintain problem solving set to guide future behaviour (Ozonoff, Pennington, & Rogers, 1991). Thus although they may be able to identify a desired goal, they may have problems identifying the steps needed to reach it. Processing speed is also commonly impaired in ASD (Luna, Doll, Hegedus, Minshew, & Sweeney, 2007) which may mean that young people with ASD may not be able to initiate behaviour steps towards a goal as they have not processed the relevant stimuli

or novel information in time. Weak central coherence (Frith & Happé, 1994) may mean that relevant contextual information necessary to understand environmental cues is impaired. This could potentially result in young people with ASD not being stimulated to undertake goal-orientated behaviour steps at the appropriate time.

These cognitive impairments may make it difficult for young people with ASD to achieve goal-directed behaviour, and indeed repeated goal achievement failure may have a significant effect on perceived self-efficacy. However, it is very important to note that none of the theoretical explanations for cognitive impairment in ASD supports the contention that young people with ASD do not set or want to achieve self determined goals. However, it may be that certain additional cognitive impairments imply that in some cases their goal-directed behaviour may vary from the typical. ASD is often associated with impairment in Theory of Mind (Baron-Cohen, Leslie, & Frith, 1985), that is the inability to attribute independent mental states to themselves and others in order to be able to predict and explain behaviour. This may mean that certain motivational factors present in typically developing young people may not be present in those with ASD. For example, aiming to please the teacher is dependent on holding a representation of the teacher's internal state of mind. In some young people with ASD, Theory of Mind impairment mean that such an internal representation is weakened or wholly absent. As such, these young people may not make use of or respond to this particular motivational factor, on either an extrinsic or intrinsic level, in relation to goal-directed behaviour. However, that is entirely different from saying that people with ASD don't set self determined goals. Based on this analysis, in the HANDS project we proposed that persuasive technology could potentially be applied to young people with ASD.

2. Methods

2.1. Objective

The objective of the analysis was to evaluate which factors mediated engagement with and effective use of the HANDS software. We see engagement as a complex process which is influenced by multiple, often context specific factors (Dexter, Anderson, & Becker, 2000; Glover & Miller, 2001; Matzen & Edmunds, 2007). Properly exploring this requires as rich a possible understanding of the teachers' and children's experiences with HANDS. Accordingly, as with the evaluation of the first prototype, a qualitative approach was employed, which we characterize as a realist interpretivist study (Hammersley & Atkinson, 2007).

Although we identified a number of cases where there had clearly been an impact on life and social skills development, our qualitative analysis was not designed to give definitive measures of children's progress.

2.2. Data collection

Data was gathered using classroom observation, and individual semi-structured interviews and matched open questionnaires. Based on the experience of the use of similar instruments in Prototype 1, appropriate adjustments were made including clarification of questions and removal of redundant items based on responses from Prototype 1 participants.

2.2.1. Teacher interviews and observations

Semi-structured interviews were undertaken with 5 teachers (associated with 10 children using HANDS) at the UK school, 2 teachers (associated with 4 children) at the Swedish School, and 2 teachers (associated with 2 children) at the Hungarian school between March and June 2011, as indicated in Table 1. The interviewer followed a specified interview guide for each interview. This focused on factors mediating engagement and use of HANDS from the perspective of both teacher and child, including interface design, technical usage issues, how it fits in with existing practice, barriers to adoption, and factors facilitating adoption. Teachers were also asked to comment on their perception of the impact that the HANDS software has had on the child's social skills and life skills.

At the UK school, 2 classroom observations were undertaken with each teacher prior to the semi-structured interview. At the Swedish and Danish schools, due to logistic constraints, one observation was undertaken prior to teacher interview. Observations were planned to allow observation of the child using the HANDS mobile device in the classroom or other setting. The observer took initial field notes during the observation which were then written up immediately afterwards in to a narrative report. In the subsequent face to face interview, the interviewer then referred to specific observational points noted within the narrative report.

All observations also included an audio recording, done using an Olympus WS-311m Voice Recorder and attached unobtrusive tie-clip microphone. Within three weeks from the date of the observation, the observer reviewed the audio recording and amended and updated the narrative record, taking into account the teacher's interview comments.

2.2.2. Teacher questionnaire

Based on the use of a similar instrument in Prototype 1, a semi-structured questionnaire was developed in tandem with the interview guide, focussing on the same areas of enquiry as specified for the interview guides. It was designed for use with teachers that, due to limitations of geography, it was not realistically possible to interview.

Table 1
Teacher attribute table by school ($n = 21$).

School	n	Gender		Average years in current role	Mainstream experience		No. Particip. Prot. 1	No. of interviews	No. of questionnaires	No. of observations
		Female	Male		Yes	No				
UK	5	4	1	9.2 years	3	2	5	5	0	10
Hungary	6	6	0	9.4 years	0	6	4	2	6	2
D'mark	5	2	3	5 years		3	1	0	5	0
Sweden	5	2	3	6.9 years	4	1	2	2	5	2

Table 2
Factors mediating engagement and Use: Factors identified in prototype 2 and prototype 1.

Factor	Number of cases where identified in PT2	Number of cases where identified in PT1
Technical factors including screen freezing, problems with synchronization to the server	8−ve 6+ve	15−ve
Graphical User Interface (GUI) Design	6+ve 2−ve	9−ve
Source Credibility	7+ve	6+ve
User Device Attachment	12+ve	6+ve
Kairos	11+ve	12+ve
Home-School Collaboration	13+ve	7+ve

Cases are + ve where the influence on engagement was positive and –ve where the influence on engagement was negative.

The questionnaire was sent to teachers at the schools in Denmark, Sweden and Hungary and completed by sixteen teachers, as indicated in Table 1. Due to the high level of English language competency at the Danish and Swedish schools, teachers completed the questionnaire in English. At the Hungarian school, colleagues in Hungary translated the questionnaire in to Hungarian. The completed questionnaires were then back translated by a professional translation service. The translators were familiar with the field of education, and the same translator undertook the translation of all questionnaires.

2.2.3. Child and parent interviews

Interviews were undertaken in April to June 2011, at the UK school only, with all of the 10 children in the HANDS test group, and separately with the parents of six of the children. Four of the parents chose not to participate in interviews, although a number of invitations to participate were issued to them. An interview guide was specified for these interviews, which focused on, from each perspective, the child's pattern of use of the phone outside and inside school, use of other phone functions, their feelings about the phone, and perception of impact on social and life skills.

Due to a combination of logistical and ethical considerations with regards to gaining consent, it was not possible to undertake interviews with parents and children in the three schools outside of the UK.

2.2.4. Characteristics of the children interviewed

All of the children were male, the average age was 15 years and 2 months at time of interview, and all had a clinical diagnosis of autism. They all had an IQ of 70 or more as measured on WISC-IV (Weschler Intelligence Scale Fourth Edition) and a VQ of 60 or more. This profile was representative of the total sample of children in the study as a whole.

It should be noted that typically epidemiological studies of ASD report a gender ratio in the order of 4 males to one female (Fombonne, 2003). Given this typical ration, the absence from girls in the study sample is not surprising.

2.3. Data analysis and reporting

A thematic analysis of the full data set was undertaken. This followed Fereday and Muir-Cochrane (2006) in using a combined deductive/inductive procedure for the coding of the data.

The initial coding structure was based on the coding structure used for the analysis of the Prototype 1 data. Codes which were redundant were removed and those that had a low level of saturation were removed or amalgamated. The ongoing fit between the codes and the data were reviewed in a series of research team meetings, where researchers drew on their professional experience to mediate the continuing development of codes, leading to revisions of the codes to provide an optimal fit to the data. Further, during the ongoing coding, a process of constant comparison between the codes and the text was undertaken (Miles & Huberman, 1994). This led to further optimization of the coding structure, including the addition of additional inductive codes derived from the data (Carley, 1990; Cohen, Manion, & Morrison, 2007).

The Nvivo software package was used to operationalize the coding structure for the coding exercise.

Identification of themes and patterns in the data was base on a descriptive cross case comparison procedure (Cohen, Manion, & Morrison, 2007; Yin, 1981). Each instance of a teacher working with a child (teacher-child dyad) was considered as a case. Firstly a case study summary was constructed for each case, with emerging themes and patterns being highlighted. Then each case was iteratively compared to the others, and the identified themes and patterns modified during this process to ensure a best fit to the overall data set.

Reliability of the coding process was established by undertaking a cross coding comparison. In the early stages of the coding process, two members of the project team independently coded 3 interview transcripts and 3 observation records.

A percentage agreement inter-reliability rating between the two coders was then calculated. This was 83% for interview transcripts and 87% for classroom observations.

3. Results

3.1. Mediating factors common across prototype 1 and prototype 2

A range of factors were identified from the thematic analysis, which influenced how and to what extent the teachers and children engaged with HANDS. These factors were drawn primarily from direct questioning – in interviews and questionnaires. Classroom observation and interviews with children also provided additional information. In some cases these sources confirmed factors articulated by teachers, but in some cases additional factors were identified. Factors were coded by teacher–child dyad case. Coding to a factor for

a particular case can be based on responses of the teacher, child, or both. There were 23 such teacher–child dyad cases in the sample. Table 2 shows the key mediating factors that were identified in Prototype 2 as well as in Prototype 1.

As Table 2 shows, when compared to Prototype 1, the perceived importance of negative technical and Graphical User Interface (GUI) issues by teachers was significantly reduced during Prototype 2, and in a number of cases explicit positive statements were made about the technical performance and the quality of the GUI. It might have been considered that perceived negative attributes of HANDS experienced by teachers participating in Prototype 1 may have affected their attitude to HANDS in Prototype 1 when compared to those teachers who did not use Prototype 1. However, a factor analysis of attitude to HANDS indicated no clear effect of prior experience with HANDS on the evaluation of Prototype 2.

As for Prototype 1, interview and observation evidence strongly suggested that the children experienced the HANDS mobile device primarily as a smartphone designed to provide voice, SMS, internet, video and audio functions, even when they were concomitantly using and responding to the specific HANDS interventions on the device. This is strongly suggestive of user device attachment as a mediating factor.

The data analysis also indicated that the ability to create behavioural interventions that could be delivered via mobile devices had encouraged teachers "extended their reach", developing interventions that could be delivered via the mobile device outside of the classroom at the right time and place (Kairos). As with Prototype 1, there was evidence to suggest that when home–school collaboration was effective, the scope for delivering such interventions in the home was potentially increased.

Teacher source credibility was also found to have a positive effect on engagement in a number of cases, as was the case in Prototype 1.

3.2. Additional mediating factors identified in prototype 2

A number of additional significant mediating factors were identified during the evaluation of Prototype 2. Although these were weakly present in Prototype 1, the data analysis indicated that they were of greater significance in Prototype 2. This may be because a) the significant technical issues experienced during Prototype 1 may have masked the detection of these factors in the evaluation of the first prototype, and b) because weak initial indications of these factors in the Prototype 1 data led to sensitization of the data collection instruments to these factors during Prototype 2 evaluation.

The incidence of these additional factors in Prototype 2 is shown in Table 3.

3.2.1. Student awareness of difficulty and motivation to change

There was some evidence from Prototype 1 that instances of effective use of HANDS by children were predicated on the individual child recognizing that an issue existed with a particular behaviour and having some level of motivation to engage with behaviour change.

The Prototype 2 data provides stronger evidence to support this recommendation. All teachers in the UK school asserted in interviews that in their perception, student awareness of an issue or difficulty and associated motivation to achieve a specified behaviour change was an important factor mediating the level of engagement with HANDS and likelihood of successful response to a particular behavioural intervention instantiated on HANDS. In 4 out of 10 teacher–child cases at the UK school, teachers indicated that their student had difficulties with awareness of specific difficulties for which interventions were introduced on HANDS, and that this had in their perception been a contributory factor to lack of response to specific interventions.

Additional subsidiary themes that were identified from the thematic analysis included: teacher and parental feelings on the potential for greater parental involvement in configuring interventions, the influence of school perspectives on the place of life and social skills in the curriculum on teacher engagement, the importance of high levels of platform reliability in initial software release for young people with ASD, and the importance of planning for battery charging in implementing mobile systems for young people with ASD. A consideration of the implication of these subsidiary themes is outside the scope of this paper, but they will be addressed in other publications.

3.2.1.1. Two cases. The operation of this mediating factor can be demonstrated by consideration of two cases, one a "negative effect" case where there was lack of sufficient consideration of student motivation and the second a contrasting "positive effect" case.

At the UK school one of teachers, at the start of the implementation of Prototype 2, felt that HANDS could potentially be used to encourage her student, John, a 15-year old male student with a diagnosis of autism, to reflect on his problematic behaviour with another student in the same class. John and the other student commonly tease and aggravate each other during lessons and break times. Consequently, the teacher programmed a series of intervention prompts onto HANDS which asked John "has student X [the other student] had a good day?" which John could select to either answer yes or no, and then a further question "if you said no, was it because you wound him up [colloquialism for aggravated him]?" which again John could answer either yes or no to. However, in practice, this intervention proved problematic, as John did not think that there was anything wrong with the way he socialized with student X or that his behaviour had any influence on the negative outcomes.

After this intervention was implemented and John had been using it for a period, the teacher requested that John change or stop the intervention because he did not like it, and instead the teacher rewrote the intervention, so that the reminder prompted John with "keep your joking with student X to break times", a more directed intervention which relied more on leveraging teacher authority, and less on

Table 3
Factors mediating engagement and Use: Factors identified in prototype 2.

Factor	Number of cases where identified in PT2
Student awareness of difficulties and motivation to change	10+ve 5−ve
Preference for mobile device based behavioural interventions	6+ve 3−ve

John's internal awareness of the issue and motivation to change his behaviour. The teacher's overall assessment of the intervention was that as John was not at all motivated to change the way he socialized and communicated with student X, the intervention failed to be effective.

In the contrasting case, another teacher reported the use of HANDS by Paul, an 18-year old student with a diagnosis of autism, who responded very successfully to an intervention designed to help him with anger management. Paul finds it difficult to manage his emotions and can get over-excited or lose his temper, especially when interacting socially or when dealing with problematic and stressful situations such as losing a valued item. He can also find it difficult to use socially appropriate language and behaviour.

In this case, the teacher, worked cooperatively with Paul, and Paul recognized the need for an intervention dealing with situations when he gets angry by *himself*. Working together, Paul and his teacher created a personal trainer intervention which gave Paul instructions on how to manage his anger prior to becoming angry and then whilst he is angry. The intervention screens included written notes and corresponding images instructing him to put his headphones on, ignore what is being said to him by other students, and not to shout and swear. The images include photos taken by his teacher using Paul's smartphone of him enacting some of the steps in the intervention.

Interview responses from Paul and his teacher, as well as classroom observations, provided evidence that that Paul has engaged well with and responded positively to the intervention. Further, as the following extract from the teacher interview indicates, in the teacher's perception, the intervention has been more successful precisely because of Paul's self-motivated desire to change his behaviour and the fact that the request to develop on the intervention on HANDS came from the student himself:

> *So I think it's got to come from them rather than us telling them what they need. Because they are capable of knowing, sometimes not realistically, but they will come up with things that they feel they need, and they're the things they will then use.*

3.2.1.2. Summary. We identified student awareness of difficulties and motivation for behaviour change as significant factors mediating engagement with HANDS and positive response to behavioural interventions. Such a finding resonates clearly with Fogg's (2003) specification of agency and internal motivation to achieve behavioural change as being a pre-requisite for persuasive systems design.

Evaluation of Prototype 2 also strongly indicates that this principle applies similarly to young people with ASD. However, in some cases it seems likely that impaired cognitive function in some children with ASD restricts their ability to identify and be aware of their own difficulties. In John's case, for example, it is possible that Theory of Mind impairment restricted his ability to recognize the effect of his behaviour on his classmate. Nevertheless, the evaluation strongly suggests that student awareness of difficulties and internal child motivation to achieve behaviour change are still significant mediating factors for children with ASD.

3.2.2. Preference for mobile device based behavioural interventions

The literature on persuasive technology indicates (Fogg, 2003) that in some instances computers can be regarded as more credible sources for persuasive messages than human actors. Our evaluation of Prototype 1 and Prototype 2 indicates that perceived teacher source credibility is a significant factor mediating engagement. We also had some weak indications from interview responses for Prototype 1 that some children may actually prefer to receive persuasive messages from HANDS than from their teacher. Accordingly we included specific questions on this area in our interview guide for Prototype 2 child interviews at the UK school, and in the linked questionnaire. In nine cases, there was evidence of a preference, including six cases at the UK school. In three cases (two at the UK school), children preferred prompts from a teacher. In six cases (four at the UK school), there was evidence to indicate that children would rather receive persuasive messages from the HANDS phone than a teacher.

A potential rationale for this preference is that many children with ASD have cognitive impairments in processing speeds (Luna et al., 2007). This rationale was explicitly or implicitly suggested by either children or teachers in 3 of the cases. For example, in one child at the UK school was using HANDS to support him in the life skills task of making toast independently. In a classroom observation he is observed completing the task successfully using HANDS as a support and voices that he prefers to receive the instructions from HANDS as opposed to from his teacher. The teacher suggests that this may be because he "can do it in his own time", that is that he has longer to process the individual intervention messages from the mobile device and can control the rate at which the messages are supplied. In the follow up interview the teacher comments:

> *I think they felt more relaxed because it was up to them to move to the next step, whereas you present someone with this long list of instructions written down. Someone with autism that you know, it works their minds when they see what they've got to do, because it does look a lot of set when it's written down. Whereas on the HANDS phones they move to the next step when they felt confident enough to do so, and they worked through it didn't they?*

However, in another case, the child expressed a preference for receiving messages from the HANDS phone because they did not perceive the HANDS phone as having the overbearing or "nagging" quality of their teacher. This rationale was suggested by parents or children in two of the cases.

In some cases, it may be that where there is impairment in executive function, as in ASD, then lots of verbal stimuli (in the form of prompts from people) can potentially be confusing. A support tool that does not overload the cognitive system, in particular concerning verbal communication, can potentially be beneficial. In these cases, mobile device preference can be regarded as potentially in alignment with teacher source credibility, i.e. the preference is for mode of reception.

In other cases, children may regard the device as being at one remove from the perceived authority of their teacher (i.e. it is less "nagging"), and thus may feel that their sense of self-determination is better preserved when they receive messages from the mobile device as opposed to from their teacher. In these cases mobile device preference would potentially be in conflict with teacher source credibility.

4. Discussion

This study further explored the factors that may mediate engagement with and use of a smartphone technology tool designed to help children with ASD with social and life skills development. Our analysis of Prototype 2, as well as confirming the role of four key mediating

factors identified in Prototype 1, has identified student awareness of difficulty and motivation to change behaviour, and preference for mobile device based interventions as additional factors mediating engagement and use of mobile technology to develop social and life skills functioning in school settings.

As noted, child and parent interviews were only undertaken at the UK School. This does perhaps mean that we should treat the generalizability of some of the conclusions to other territories with caution. However, in respect of the key mediating factors identified in the paper, if these are based on cognitive features typically present in young people with ASD, it is difficult to envisage, a priori, any cultural factors which would have a significant effect on the generalizability of the results.

Based on our evaluation of Prototype 1, our main recommendations were (see Mintz et al., 2012) that:

1. In the implementation of similar mobile technology solutions in schools, consideration should be given to uses of the technology not just in school, but in out of school contexts as well. This should include giving specific guidance to teachers and parents on how they could plan for out of school use.
2. As increased user attachment leads to users responding more positively to persuasive messages, designers should ensure that the mobile persuasive application can be loaded on the young person's primary mobile device. This led to the conclusion that multi-platform design for such applications is highly preferable.

The evaluation of Prototype 2 gives further evidential support to these guideline recommendations. We also propose further guidelines based on the additional mediating factors identified in Prototype 2.

4.1. Guideline 1: work with the children to identify needs

Our evaluation indicates that in line with the general literature on persuasive technology, mobile persuasive interventions for children and young people with ASD are more likely to be effective if the child is both a) aware of difficulty/issue and recognizes at such, and b) motivated to achieve positive behaviour change. Teachers should develop interventions for similar systems based on a recognition of the fact that student awareness of needs and internal motivation for behaviour change is a key mediating factor. Rather than starting from a position of "teacher knows best", they should work collaboratively with children and young people to identify interventions that the child or young person themselves assents to. Further, strong consideration should be given, in school based implementations, of such systems, to increasing the autonomy of the child or young person in terms of their level of control over the interventions that are developed for them on HANDS-like systems. Although some level of adult supervision and facilitation will always be required in school based implementations, the balance should be "tipped" further towards the child's own control of the development of interventions.

4.2. Guideline 2: identifying which children will benefit most

In Guideline 1, we recommend that teachers focus on identifying needs from the child's perspective. This is clearly crucial, however, some children will, due to cognitive impairments, find it much more difficult to be aware of social and life skill difficulties that are important factors contributing to their exclusion from educational and social opportunities. In such cases, instantiating behavioural messages on HANDS-like systems is not likely to contribute to bringing about positive behaviour change.

Alternatively, our evaluation indicates that some children with ASD may be particularly well suited to the use of this technology. Children who do have an awareness of social and life skill difficulties that are proving to be obstacles to inclusion, and who are concomitantly motivated towards behaviour change, are much more likely to prove receptive. Further, our finding that some young people with ASD may have a preference to receive behaviour change messages from mobile devices rather than from adults is particularly important, especially given the existence of two potential explanatory accounts for this phenomenon. The first of these accounts, an underlying impairment in cognitive processing speeds, could also have potential application to other groups with this type of impairment, such as young people with Attention Deficit/Hyperactivity Disorder (see Mayes & Calhoun, 2007). The second account, which explains the preference based on the young person's desire for autonomy, i.e. it's better than being nagged by your teacher, further emphasizes the need to put more stress on the views of young people with ASD when making decisions about which interventions to implement and how to structure them.

Overall, our results certainly indicate that in the implementation of HANDS-like systems, some children but certainly not all are likely to benefit from receiving behaviour change messages from mobile devices. A blanket wide approach, where the technology is used indiscriminately with a wide population of young people with ASD, is likely to be wasteful and in a number of cases non-productive. The experience with HANDS suggests that teachers, as well as other intermediaries such as parents, who have an ongoing reflexive relationship with the young people, have a significant role to play in determining which individuals are likely to benefit from the use of persuasive mobile technology. However, we also sound a note of caution on relying on teacher (or parental) evaluations alone. Psychology assessments of the cognitive profile of people with ASD such as the Vineland Adaptive Behaviour Scales (Carter et al., 1998) are routinely used in educational settings to measure adaptive functioning in a number of domains (see Charman, Howlin, Berry, and Prince (2004), for an example of such use). The use of such standardized assessment information in combination with teacher judgements is likely to lead to optimized targeting of the use of HANDS-like systems. Additionally, although it is outside of the scope of the current paper, there is clearly potential to develop, based on the evaluation indicators from the HANDS project, a standardized instrument specifically for screening children with ASD who have a cognitive profile likely to benefit from the use of persuasive mobile technology.

4.3. Use on other platforms

Since the implementation of HANDS, there has been a rapid adoption of tablet devices in the developed world. In the USA, for example, in less than two years, nearly 40 million tablets were in use amongst mobile subscribers, outpacing smartphones which took seven years to achieve the same level of adoption (COMScore, 2012). It is certainly the case that HANDS-like systems will be candidates for implementation on both smartphone and tablet platforms. However, one of the key features of HANDS was its emphasis on portability, and from a persuasive

design perspective, the potential to leverage Kairos. The size of tablet devices may limit such portability. It is, however, quite possible that users, in conjunction with parents and teachers, may adopt a multi-platform approach, receiving persuasive messages from HANDS-like systems on both smartphone and tablet devices, perhaps using the latter when they are out and about, and the former when in school or at home.

Acknowledgements

This work was supported by the European Commission, [Grant No. 224216]. Thanks are due to other members of the consortium including teachers and other professionals at test site schools, for their support and assistance in the work described in this project.

References

Amber, N., Schrodt, P., Witt, P., Elledge, N., Jernberg, K., & Larson, L. (2009). A meta-analytical review of teacher credibility and its associations with teacher behaviors and student outcomes. *Communication Education, 58*(4), 516–537.
Aurora. (2000). *The Aurora project*. Retrieved 25.11.11, from. updated 2008. http://www.aurora-project.com.
Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. http://dx.doi.org/10.1037/0033-295X.84.2.191, American Psychological Association.
Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology, 4*(3), 359–373, Guilford Publications. Retrieved from. http://www.atypon-link.com/GPI/doi/abs/10.1521/jscp.1986.4.3.359.
Bandura, A. (1991). Human agency: the rhetoric and the reality. *American Psychologist, 46*(2), 157–162. http://dx.doi.org/10.1037/0003-066X.46.2.157.
Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*(1), 37–46.
Bernard-Opitz, V., Sriram, N., & Nakhoda-Sapuan, S. (2001). Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. *Journal of Autism and Developmental Disorders, 31*, 377–384.
Brown, D. J., McHugh, D., Standen, P., Evett, L., Shopland, N., & Battersby, S. (2011). Designing location-based learning experiences for people with intellectual disabilities and additional sensory impairments. *Computers & Education, 56*(1), 11–20.
Carley, K. (1990). Content analysis. In R. E. Asher (Ed.), *The encyclopaedia of language and linguistics*. Edinburgh, UK: Pergamon Press.
Carmien, S. (2004). Task support for people with cognitive impairments and their caregivers. *American Journal of Occupational Therapy, 4*, 1–4.
Carmien, S., Dawe, M., Fischer, G., Gorman, A., Kintsch, A., & Sullivan, J. F. (June 2005). Socio-technical environments supporting people with cognitive disabilities using public transportation. *ACM Transactions on Computer-Human Interaction, 12*(2), 233–262.
Carter, A. S., Volkmar, F. R., Sparrow, S. S., Wang, J.-J., Lord, C., Dawson, G., et al. (1998). The Vineland Adaptive Behavior Scales: supplementary norms for individuals with autism. *Journal of Autism and Developmental Disorders, 28*(4), 287–302.
Charman, T., Howlin, P., Berry, B., & Prince, E. (2004). Measuring developmental progress of children with autism spectrum disorder on school entry using parent report. *Autism: The International Journal of Research and Practice, 8*(1), 89–100. http://dx.doi.org/10.1177/1362361304040641.
Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in education* (6th ed.). London, UK: Routledge Falmer.
COMScore. (2012). *2012 Mobile future in focus* [Online]. Available. http://www.comscore.com/Press_Events/Presentations_Whitepapers/2012/2012_Mobile_Future_in_Focus [Accessed 17.07.12].
Dautenhahan, K., & Werry, I. (2004). Towards interactive robots in autism therapy: background, motivation and challenges. *Pragmatics and Cognition, 12*(1), 1–35.
Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: a macrotheory of human motivation, development, and health. *Canadian Psychology/Psychologie Canadienne, 49*(3), 182–185. http://dx.doi.org/10.1037/a0012801.
Dexter, S. L., Anderson, R. E., & Becker, H. J. (2000). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Research on Computing in Education, 31*(3), 222–232.
Farr, W., Yuill, N., & Raffle, H. (2010). Social benefits of a tangible user interface for children with Autistic Spectrum conditions. *Autism, 14*(3), 237–252.
Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 80–92.
Fogg, B. J. (2003). *Persuasive technology. Using computers to change what we think and do*. San Francisco, CA: Morgan Kaufman Publishers.
Fogg, B., Cuellar, G., & Danielson, D. R. (2008). Motivating, influencing, and persuading users. In J. A. Jacko (Ed.), *The handbook of human-computer interaction* (pp. 359–370). CRC Press.
Fogg, B. J., & Eckles, D. (2007). *Mobile persuasion. 20 perspectives on the future of behavior change*. Stanford: Stanford Captology Media.
Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *Journal of Autism and Developmental Disorders, 33*(4), 365–381.
Frith, U., & Happé, F. (1994). Autism: beyond "theory of mind". *Cognition, 50*(1–3), 115–132, The MIT Press.
Gentry, T., Wallace, J., Kvarfordt, C., & Lynch, K. B. (2010). Personal digital assistants as cognitive aids for high school students with autism: results of a community-based trial. *Journal of Vocational Rehabilitation, 32*, 101–107.
Glover, D., & Miller, D. (2001). Running with Technology: the pedagogic impact of the large-scale introduction of interactive whiteboards in one secondary school. *Technology, Pedagogy and Education, 10*(3), 257–278.
Hammersley, M., & Atkinson, P. (2007). *Ethnography in practice* (3rd ed.). London, UK: Routledge.
HANDS Project. (2011). *The HANDS project*. Retrieved 28.12.11, from. www.hands-project.eu.
Haskins, B. G., & Silva, J. A. (2006). Asperger's disorder and criminal behavior: forensic psychiatric considerations. *Journal of the American Academy of Psychiatry and the Law, 34*, 374–384.
Howlin, P. (2004). *Autism and Asperger Syndrome: Preparing for adulthood*. London, UK: Routledge.
Jason, J. T., & Herring, J. E. (2005). Teacher influence in the classroom: a preliminary investigation of perceived instructor power, credibility, and student satisfaction. *Communication Research Reports, 22*(3), 235–246.
Lindström, J. (2007). Safe navigation with wireless technology. In P. R. W. Roe (Ed.), *Towards and inclusive future: Impact and wider potential of information and communication technologies*. Brussels: COST.
Luna, B., Doll, S. K., Hegedus, S. J., Minshew, N. J., & Sweeney, J. A. (2007). Maturation of executive function in autism. *Biological Psychiatry, 61*(4), 474–481. http://dx.doi.org/10.1016/j.biopsych.2006.02.030.
Matzen, N. J., & Edmunds, J. A. (2007). Technology as a catalyst for change: the role of professional development. *Journal of Research on Technology in Education, 39*(4), 417–430.
Mayes, S. D., & Calhoun, S. L. (2007). Learning, attention, writing, and processing speed in typical children and children with ADHD, autism, anxiety, depression, and oppositional-defiant disorder. *Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence, 13*(6), 469–493.
Mechling, L. C., Gast, D. L., & Seid, N. H. (2009). Using a personal digital assistant to increase independent task completion by students with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 39*(10), 1420–1434. http://dx.doi.org/10.1007/s10803-009-0761-0.
Meschtscherjakov, A. (2009). Mobile attachment – Emotional attachment towards mobile devices and services. In The Proceedings of the 11th International Conference on human-computer interaction with mobile devices and services, Mobile HCI'09. Bonn, Germany.
Miles, B., & Huberman, N. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). CA: Sage.
Mintz, J., Branch, C., March, C., & Lerman, S. (2012). Key factors mediating the use of a mobile technology tool designed to develop social and life skills in children with Autistic Spectrum Disorders. *Computers & Education, 58*(1), 53–62. http://dx.doi.org/10.1016/j.compedu.2011.07.013.
Mitchell, P., Parsons, S., & Leonard, A. (2007). Using virtual environments for teaching social understanding to 6 adolescents with autistic spectrum disorders. *Journal of Autism and Development Disorders, 37*(3), 589–600.
Moore, D., & Taylor, J. (2000). Interactive multimedia systems for students with autism. *Journal of Educational Media, 25*(3), 169–177.
Ozonoff, S., Pennington, F.,B., & Rogers, J.,S. (1991). Executive function deficits in high-functioning autistic individuals: relationship to Theory of Mind. *Journals of Child Psychology and Psychiatry, 32*(7), 1081–1105.

Parsons, S., Mitchell, P., & Leonard, A. (2004). The use and understanding of virtual environments by adolescents with autistic spectrum disorders. *Journal of Autism and Development Disorders, 34*(4), 449–466.
Patterson, D., Liao, L., Gajos, K., Collier, M., Livic, N., Olson, K., et al. (2004). In N. Davies, E. D. Mynatt, & I. Siio (Eds.). *UbiComp 2004: Ubiquitous computing, Vol. 3205* (pp. 433–450). Berlin, Heidelberg: Springer Berlin Heidelberg. http://dx.doi.org/10.1007/b99948.
Ploug, T., Hasle, P., & Oinas-Kukkonen, H. (Eds.), (2010). *Proceedings of the 5th international conference on persuasive technology*. New York: Springer.
Rayner, C., Denholm, C., & Sigafoos, J. (2009). Video-based intervention for individuals with autism: key questions that remain unanswered. *Research in Autism Spectrum Disorders, 3*(2), 291–303.
Shea, V., & Mesibov, G. (2005). Adolescents and adults with autism. In (3rd ed.). In F. R. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.)., *Handbook of autism and pervasive developmental disorders, Vol. 1* (pp. 288–311) Hoboken, NJ: Wiley.
Tentori, M., & Hayes, G. (2010). Designing for interaction immediacy to enhance social skills of children with autism. In J. Bardram, M. Langhenreich, K. Truong, & P. Nixon (Eds.), *Proceedings of the 12th ACM international conference on ubiquitous computing* (pp. 51–60). New York, NY: The ACM Press. http://dx.doi.org/10.1145/1864349.1864359.
Thweatt, K. S., & McCroskey, J. C. (1998). The impact of teacher immediacy and misbehaviors on teacher credibility. *Communication Education, 47*, 348–358.
Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Lin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45*(1), 135–170.
Wainer, A. L., & Ingersoll, R. (2010). The use of innovative computer technology for teaching social communication to individuals with autism spectrum disorders. *Research in Autism Spectrum Disorders, 5*, 96–107.
Wallace, S., Parsons, S., Westbury, A., White, K., White, K., & Bailey, A. (2010). Sense of presence and atypical social judgments in immersive virtual environments. Responses of adolescents with Autism Spectrum Disorders. *Autism: The International Journal of Research and Practice, 14*(3), 199–213. http://dx.doi.org/10.1177/1362361310363283.
Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. *Journal of Autism and Developmental Disorders, 9*, 11–29.
Yin, K. (1981). The case study crisis: some answers. *Administrative Science Quarterly, 26*, 58–65.