Challenges in developing new technologies for special needs education: a force-field analysis

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ABSTRACT

Introduction of new technologies for use in special needs education requires careful design to ensure that their use is suitable for the intended users in the context of use and that learners benefit from the experience. This paper discusses issues that influence implementation of collaborative technologies designed to support learning of social communication skills in young people with autism. Taking a reflective view of lessons learned during the COSPATIAL project, a force-field analysis was applied to identify positive factors contributing to successful application development and negative factors that disrupted progress and implementation of the software. On the basis of our experience in the COSPATIAL project, recommendations for future projects are made.

1. INTRODUCTION

Autism Spectrum Conditions (ASC) affect behaviour and the ability to communicate and interact socially (Baily et al, 1996). Social competence, entailing a child's capacity to integrate behavioural, cognitive and affective skills in order to adapt flexibly to diverse social contexts and demands is one of the core skills that is impaired in children with High Functioning Autism. Social incompetence adversely affects a child's ability to learn in formal and informal educational settings, and to interact appropriately with other children (Bauminger, 2002). A variety of technologies have been used to train social competence of children with ASC. These include video modeling (Nikopoulos and Keenan, 2004), virtual reality (Parsons and Cobb, 2014), socially assistive robots (Dautenhahn and Werry, 2004) and multi-user or multi-touch tabletop surfaces (Giusti et al, 2011). To date, well-established practices for the design of technology to support therapeutic and educational interventions for these children are lacking (Davis et al, 2010).

A "Force Field" analysis is a framework for looking at the factors (forces) that influence the achievement of a designated objective and has recently been applied to the field of virtual reality for motor rehabilitation (Weiss et al, 2014). It identifies the positive forces that help an application to move towards achieving its goal (driving forces) and the negative forces causing it to become more distant from its goal (restraining forces). This paper presents a retrospective force-field analysis on COSPATIAL (http://cospatial.fbk.eu/) an EU-funded project whose goal was designing and creating collaborative technology applications to improve social competence of children with High Functioning Autism. The project investigated two categories of technologies for collaborative interaction: Collaborative Virtual Environments (CVE) and Shared Active Surfaces (SAS). Over a three year period, multidisciplinary design teams comprising technology developers, autism specialists, human factors researchers, teachers, and young people with autism located in three countries (Italy, Israel and UK) to develop software applications to support learning of social communication skills using each technology. 43 teachers from 8 schools and 85 children (48 typically developing and 37 with ASC) were involved in participatory design and evaluation of CVEs and a further 12 teachers from 5 schools and 24 children with ASC were involved in the formative SAS studies.

The analysis was based on examination of the accumulated evidence and lessons learned throughout the three-year project with the purpose to reflect upon the causes of specific design outcomes and generate recommendations for future technologies. Four major driving forces and four major restraining forces relating to the field of collaborative technology-based social competence training for children with ASC (as well as other related applications) were identified.

2. DRIVING FORCES OF COLLABORATIVE TECHNOLOGIES

2.1 Affordances of collaborative technology

CVEs and SASs offer affordances that facilitate the design of collaborative activities. CVEs permit distributed synchronous communication, enabling children to talk directly to each other and work collaboratively but without physical proximity; SASs provide co-located, action-level collaboration (e.g., touching together). These technologies may be designed to empower teachers, allowing them to flexibly control the pace of a session; they can also empower children by enabling them to become actively involved in the educational activities.

2.2 Use of a strong theoretical model to inform design of learning tasks

COSPATIAL used the principles of Cognitive-Behavioural Therapy to inform the design of technology applications, and their intended mode of use with children. Although COSPATIAL adhered to CBT principles, our prototypes did not require a fully compliant CBT intervention model. Nevertheless, care was taken to abide by the model's tenets in order to remain consistent with its underlying assumptions as well as the evidence that supports its use.

2.3 User involvement in the design process

Co-design and participatory design are needed to develop prototypes that are likely to be more acceptable to target users, even if they sometimes present significant challenges (due to constraints related to time, effort and technical complexity). It is crucial to implement the process in a manner that ensures sufficient time to involve all stakeholders so that they can achieve a comprehensive understanding of the applications and can learn to interact with each other. Since participatory design processes are not always feasible, different levels of feedback from users may need to be elicited. In addition, it is important to recognize the challenge of the design process when co-designing with a group of people with different backgrounds, levels of involvement, geographical locations.

2.4 Personalisation of educational technology

There is a strong need for teachers and therapists to be able to personalize technology tools. There will be less chance of adoption of a given technology if the design process produces a tool that is too specific to the original design objective (e.g., only social collaboration) or does not enable sufficient variations in levels of ability or styles of practice. Embracing a tactic of personalization will ensure a much wider usage in terms of educational objectives, target problems and the age and abilities of the children. Although personalization should aim to adapt features of the tool to meet a child's skills, it should also provide a truly flexible tool for the teachers to custom-build learning experiences.

3. RESTRAINING FORCES OF COLLABORATIVE TECHNOLOGIES

3.1 Cumbersome and/or expensive technologies

Technologies (particularly large tabletops or complex virtual reality systems) may be too cumbersome and expensive for daily use. This will likely limit and even impede their implementation in the school system. In educational frameworks that are dedicated specifically to children with ASC, the purchase and installation of specialized equipment and software may be feasible. However, in settings where mainstreaming is provided via special classes for children with ASC, the use of cumbersome equipment is less feasible. It is necessary to continue to explore lost-cost, low-encumbrance platforms to deploy the prototypes. For example. use of the multi-mice version of two of the COSPATIAL SAS applications that had originally been designed for a multi-touch tabletop (Weiss et al, 2011) and COSPATIAL CVEs Block Challenge and Talk2U running on standard laptops (Cobb et al, 2014). Educational software must take into account requirements related to the context of use (e.g., a classroom); constraints (e.g., cost, size) should be identified at an early development stage. Nevertheless, in the context of COSPATIAL the possibility of experimenting with expensive and cutting-edge devices allowed us to identify and explore patterns of use (i.e., constraining the interaction via multiple, simultaneous actions) that were then scaled down to more affordable solutions (e.g., multi-mice approach).

3.2 Need for on-site instruction and support in technology usage

Despite widespread positive expression of interest in using collaborative technologies on the part of teachers, clinicians and parents, actual usage will only take place with on-going, on-site instruction and support. It is necessary to accompany the transition between research efforts (such as the COSPATIAL project) and actual use in everyday practice by means of projects that are more oriented toward development of learning resources and best-practices. It is necessary to identify constraints within the special education sector for children with ASC that facilitate the adoption of technology. For example, adoption of cumbersome systems in mainstream schools will be more difficult than in specialised schools or after-school centres. Successful adoption of technology will be more likely if they are tailored to the constraints of the setting in which they will be used. In planning the transition from a research prototype to a system actually used in real settings, the robustness of the software itself is not enough. Deploying the technology depends on maintenance and support which can only be assured by a commercial company. Such involvement need not happen from the outset; indeed, not having to satisfy the interests of specific companies gave COSPATIAL greater flexibility in exploring different platforms without being committed at too early a stage. However, commercial support for full exploitation is essential.

3.3 False expectations and misunderstandings during the design process

Although participatory design is a potentially effective approach for creating collaborative technologies, care must be taken throughout the entire process in order to avoid false expectations which can impede any positive effect. Thus, co-design must be implemented with emphasis on communication and clarification, especially when the teams are geographically distributed and have different backgrounds and languages. The judicious use of tools to trace decision-making and concept clarification help track when and why decisions are taken. In the case of ASC, including children in the design process is problematic because of their difficulties with Theory Of Mind (understanding what the others think). Although rapid prototyping is often suggested as a remedy to enhance visualisation of the proposed design, the notion of "rapid" is very subjective; it may be too long relative to the overall length of the project where evaluation cannot commence until the software is more advanced.

3.4 Insufficient evidence-based practice

The lack of conditions that favour optimal research designs holds back progress by reducing the impact of a technology's results. Formative studies should be initially favoured in design-oriented projects especially when the duration is limited to three years and less. However, it is essential to fund longer-term intervention studies in order to achieve a solid base of evidence for the practice of novel technology applications. The experience with COSPATIAL is that the scientific community (both in the field of autism and in the field of human-computer interaction) is keen to accept results of small studies and these forums may help to fund the type of pilot and single case study design research that will lead to the funding of full, evidence-based research designs.

4. RECOMMENDATIONS

The difficulties experienced by COSPATIAL in aiming to both develop and evaluate software prototypes is not unique to autism research. Although a project evaluation plan needs to be realistic and adaptable during its lifecycle, it can be difficult to anticipate problematic issues when working with new design teams to develop novel applications that have not previously been used in an educational setting. Retrospective use of the force-field analysis of the COSPATIAL project enabled us to identify positive and negative factors that influenced project progress and outcome. On the basis of this reflective review, a number of recommendations are suggested that may facilitate future development of educational software using new technologies, intended both for special needs and mainstream educational contexts:

- *Establish a core design team representing key stakeholder groups*. The use of a co-/participatory design is not a trivial undertaking. In order to fully take advantage of this approach, it should be seriously applied from the beginning of the project by using appropriate methodological approaches (which may differ for individual users or groups of users) and explicitly controlling the process. The participation of all the stakeholders is fundamental but we have learned the presence of a core team of experts that helps to liaise with the core users (teachers and children) is essential.
- *Include all stakeholders in the design process*. Input from the target users (in this case children with high functioning ASC together with teachers/therapists) was vital for promoting greater acceptance of the developed software. Thus, co-/participatory design should be employed in projects even if the target population has significant disabilities. Children with ASC can be included in the participatory design process, although it is necessary to adapt the activities to suit their unique characteristics as well as their individual needs (Millen et al, 2012). Moreover, there should be appropriate expertise represented within the research team to enable such participatory design processes to take place.
- *Do not assume shared understanding between design partners*. In any multi-disciplinary co-design team, it is essential to manage the interactions and the expectations, to be clear about the goals and the procedures, to negotiate the level of participation and the different responsibilities of the people involved and to effectively, but precisely, trace the decisions taken during the process.
- *Base learning task design on learning theory but do not be afraid to apply 'cautious flexibility' and adapt it to suit user needs.* CBT proved to be an effective theoretical framework to guide the design of the

prototypes by providing a context to conceptualise the affordances offered by the CVE and SAS prototypes and to explore the advantages and limitations of those affordances in meeting the requirements of the CBT principles (e.g., dividing the session into two interleaved parts for learning (cognition) and experiencing (behaviour). The CBT model also provided us with specific techniques and procedures, such as concept clarification and role-playing.

- *Conduct technology development and testing in the context of use.* Implementation of new technology on the classroom or other learning environment beyond the lifetime of the project is more likely to be successful if all considerations relating to the context of use have been properly taken into account. Setting up demonstrations of pre-configured technology developed in the research lab is not sufficient; the equipment must be set up and used by teachers and other stakeholders in situ.
- *Utilise affordances of the technology that directly address core learning needs*. The cost and inconvenience of using new technologies in education will be worthwhile if the added value to students is evident. Exploiting the affordances of CVE and SAS related to their inherent collaboration dimensions for tasks directly related to the core diagnostic difficulties of autism, offers learning tools that may not be available through other means and, in COSPATIAL, led to additional applications for other children with special needs.

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