Interaction Design: a Multidimensional Approach for Learners with Autism

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ABSTRACT
In the special education context of children with autism, the design of educational software needs to focus on their unique learning styles. In this study, results of a survey in Irish Primary Schools, and interviews with tutors, indicate that characteristics of learners with autism need to be more integrated into the design process. An interaction model, based on Norman's and Abowd and Beale's models, provides a basis for mapping special user requirements and instructional strategies onto a model suited to the learner with autism. We propose this extended interaction model as a basis for design guidelines for effective educational software for these special needs learners.

Keywords
Autism, educational software, learning styles, interaction design, scaffolding

ACM Classification Keywords
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – User-centered design, Theory and methods

INTRODUCTION
The context for this study is the use of special education software with learners with autism in Irish Primary Schools. Learners with autism can suffer, to varying degrees, from the triad of impairment, namely abnormal communication, abnormal social development and ritualistic behaviour and resistance to change. The educational software design process for the user with autism must adapt specifically to the needs of its target audience. At the outset of this study, in informal interviews, teachers agreed that technology is attractive to the learner with autism. However, it emerged that interface design needs to be revised, if it is to offer optimal opportunities for understanding and learning to special needs learners. Perspectives on autistic learning, and strategies for addressing these learning needs, are documented in the literature, with a view to improving instructional interventions (non technology-based). [4, 10, 12, 15, 18, 20].

Furthermore, Mertens and McLaughlin [16] report that there is a paradigm shift from the 'deficit' model, to one that requires the environment to respond to the abilities of the learner, using a more effective approach to special education that emphasises the strengths of the individual. Similarly, Siegel recommends a focus on 'autistic learning styles' in an approach that emphasises the learner's abilities [20]. She poses the question: "How do we rewire around the weaknesses and utilize relative strengths as best we can"? Existing non technology-based educational intervention programmes for young children with autism revolve around building on their strengths. For example, the TEACCH intervention programme (**T**reatment and **E**ducation of **A**utistic and related **C**ommunication handicapped **CH**ildren) involves a structured teaching approach and the use of visual materials [19]. Strengths that are typically associated with autism are: *Special interests*, *Rote memory skills*, *Visual processing*, *Attention to detail* and *Affinity for routine*. In parallel with building on these strengths, intervention programmes aim to alleviate the special needs of the autistic child that inhibit learning, which are documented as difficulties with: *Verbal expression* (normal speech may be very delayed or non existent), *Auditory processing* (a difficulty in retaining spoken instructions), *Attention span* (short span), *Organisational skills* (e.g., problems in managing one's tasks or activities), *Generalisation of skills* and *Transitions* (from one task to the next) [8, 11, 13, 18, 20].

EDUCATIONAL SOFTWARE STUDY
We have investigated the use of educational software with young learners with autism, in order to gain insight into its use and effectiveness as an educational aid. Initial interviews with tutors, and our national survey of Irish Primary School teachers have indicated that there is a high level of use of special education software [5]. However, a majority of teachers surveyed, working with young learners who are autistic, report significant shortcomings with the current software in use in their classrooms. Difficulties that have come to light include insufficient error control and v.

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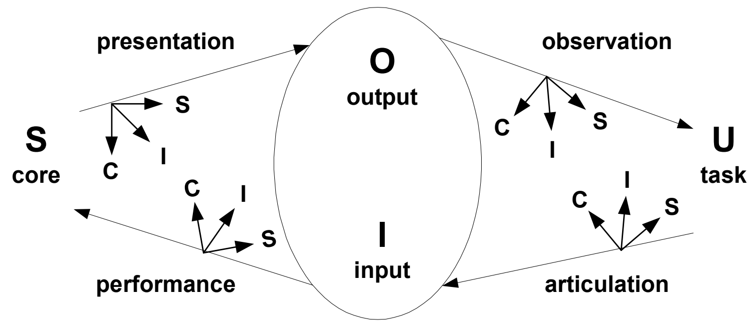

Figure 1 Interaction Model (adapted from Abowd and Beale, 1991)

inappropriate audio feedback on error, and other user problems. We believe that more consideration should be given to autistic learner characteristics and appropriate instructional strategies, when their educational software is being designed.

INTERACTION DESIGN

We propose a multidimensional approach to interaction design that is responsive to the needs of young learners with autism. It incorporates strategies recommended in the literature that build on autistic learner strengths and support learner difficulties. We present an account of work-in-progress on a proposed theoretical design framework [6]. Our instructional framework uses as a base Norman's interaction design model [17] and the extension to that as devised by Abowd and Beale [1]. Our model includes the addition of instructional design aspects to that existing interaction model. The rationale for choosing the Norman model as a basis for our investigation is that Norman has emphasised the 'gulfs of execution' and 'gulfs of evaluation' [9]. These 'gulfs' identified by Norman provide a convenient way of representing the problems reported by Irish teachers in our software survey on the use of educational software with young autistic learners.

We consider that the three main components of computer-supported learning (CSL), for the learner with autism, can be seen as falling under the headings of:

- the appropriate learning scenario or Content (C)
- the required special education approach or Instruction (I)
- the amount of cognitive guidance and support provided by the system or Scaffolding (S).

According to Ashman and Conway, the term 'scaffolding' is linked to the work of Vygotsky, whereby support is provided to learners "to enable them to achieve objectives they would not have achieved without that support" [3]. For normally-developing learners scaffolding or instructional assistance would be gradually reduced, but this may not be the case for certain of the learning difficulties associated with autism.

We examine this multidimensional component approach, namely Content, Instruction and Scaffolding (CIS), and emphasise the importance of catering for autistic needs, at each component level in the learning process. We use a three-dimensional vector to represent the crucial aspects of interaction, in relation to these CIS components, at each point in the interaction cycle. This CIS approach is integrated into the Norman and Abowd and Beale model as illustrated in Figure 1. Specific interaction design guidelines need to be devised for all three CIS components, for each of Abowd and Beale's translation arcs or quadrants in the interaction cycle. For each learning scenario, a 'scaffolding' approach, supported also by appropriate instructional strategies, along specific translation arcs in the interaction, i.e., Articulation, Performance, Presentation or Observation, can help to ensure that the cognitive load and general usability of the software system is appropriate for the young learner with autism.

DESIGN GUIDELINES FOR LEARNERS WITH AUTISM

Instructional design strategies for the Content, Instruction and Scaffolding components need to be integrated into the interaction design, depending on the learner's needs at a given point in the interaction cycle. In their original work, a treatment of the four translation arcs, Abowd and Beale [1] discuss the relative lengths or 'distances' along the arcs. They suggest that there should be tradeoffs between distances so that, for example, the system should absorb the greater workload thus making the use of the application easier for the user. This approach would appear to suit the interaction needs of the user with autism, so that on the system side of the interaction a lot of support is offered to the user (for example on the Performance arc), thus supporting or scaffolding the learner's input interactions on the Articulation arc. Learner requirements can be summarised in a Requirements Matrix, as compiled in Table 1. Table 1 brings together all aspects of a learning scenario that may be present when a learner with autism uses special education software to support his learning. The combinations in Table 1 then need to be further refined to allow the designer to focus on specific learner strengths and needs, for a given quadrant in the interaction cycle.

Table 1 Requirements Matrix for Learners with Autism

Computer Supported Learning Component	**Quadrant in the Interaction Cycle**	**Learner Characteristics: Learning strengths to be engaged**	**Special needs to be supported**
Content Instruction Scaffolding	Presentation Observation Articulation Performance	Special interests Rote memory skills Visual processing Attention to detail Affinity for routine	Verbal expression Auditory processing Attention span Organisational skills Generalisation of skills Transitions

Table 2 User Requirements in the Presentation Quadrant

Computer Supported Learning Component	**Quadrant in the Interaction Cycle**	**Learner Characteristics: Learning strengths to be engaged**	**Special needs to be supported**
Content	Presentation	Special Interest Visual processing	Auditory processing
Instruction	Presentation	Attention to detail Affinity for routine Rote memory skills	Attention Span Generalisation of skills
Scaffolding	Presentation		Transitions Organisational skills

Current work-in-progress involves a categorisation of the autistic user requirements for each quadrant, so that the relevant instructional strategies can be incorporated into a design specification. For example, the combinations suggested for learner support in the Presentation quadrant are summarised in Table 2. Specific learner strengths and difficulties are associated with a particular learning component, i.e., Content, Instruction or Scaffolding.

In similar manner the user requirements for the Observation, Articulation and Performance quadrants need to be documented. An approach being considered is to employ the Unified Modeling Language (UML) notation, beginning with Use Cases for learning scenario description, and deriving Sequence Diagrams to depict the user activity for a given learning scenario. Our design decisions will be guided by existing literature and our field research on autistic learner characteristics, as indicated in Tables 1 and 2. These decisions will then be examined by tutors who have already provided input to our study. Relevant literature includes recent medical studies of magnetic resonance imaging (fMRI) that indicate cognitive, attention and motor function abnormalities in the cerebellum of those with autism [2]. These medical studies support our inclusion of the Scaffolding component in the model, as their findings have shown, for example, that users with autism need support and extra time to make a transition from one task to the next (see Table 2, which specifies support for 'Transitions').

DISCUSSION

The ultimate aim of our study is to compile a set of guidelines for special education software design that is appropriate for the learner with autism. The immediate next phase will concentrate on designing and implementing software prototypes, to test the validity of our model in classroom settings. This augmented interaction model, if proven to be predictive of autistic user needs, could make a significant contribution, leading to the formation of specific guidelines for accessibility of digital artifacts, for users with autism. The guidelines could expand upon the generic guidelines that exist already for users with special needs, e.g., W3C Web Accessibility Initiative (WAI) [21] or IMS Project guidelines [14]. To date the guidelines that relate to interaction design for cognitive impairment are general in nature and not related sufficiently closely to the needs of young children with autism. This new multidimensional model, and its emerging guidelines, should help to inform designers of special education software, and thus lead to more user satisfaction and learning success in the young autistic user community. Also, as quoted by Benyon et al. [7] "if a design works well for people with disabilities, it works better for everyone".

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