

Embodied Conversational Agents for Education in Autism

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1. Introduction

Individuals with high-functioning autism and Asperger Syndrome find everyday social interactions very challenging due to their impairments in language, communication and social skills (Rapin & Tuchman, 2008). As their IQ scores are in the average and above range, they are typically placed into mainstream schools and face complex social interactions with their peers and educators daily. Individuals with autism have a strong preference for sameness and so often feel more comfortable interacting with computers and robots than their peers (Putnam & Chong, 2008). A computer program providing a virtual human tutor that teaches social skills can capitalise on this preference for technology, while working towards improved social competence. Such an approach is expected to provide a motivating, non-judgemental environment in which to develop social skills, while offering a tool that can be used independently by the individual, relieving pressure from carers, educators and therapists working with the learner. While little existing research has focussed on using embodied conversational agents (ECAs) for teaching children with autism, what has been done has led to promising outcomes (see Bosseler & Massaro, 2003; Tartaro & Cassell, 2006). In developing an ECA for improving social competence in children with autism, the particular needs of these individuals must be taken into account. Very importantly, this means that the tutor must present content in a way that suits the learning style and sensory needs of the learner, provide assessment tasks that are both appropriate and relevant and interpret the results of these assessments in a meaningful manner.

2. Embodied conversational agents

Embodied Conversational Agents (ECAs) are autonomous, animated virtual agents, typically human in appearance, that interact with users in real-time dialogue, recognising and performing both speech and gesture, much akin to real human-to-human interaction (Cassell, 2001). To implement a virtual embodied conversational agent requires use of a range of cutting edge technologies and significant computational power. Thus, most agents referred to as ECAs are not truly embodied in the sense of the given definition, with many relying on heuristics to give the appearance of embodiment while being computationally efficient enough to run on standard personal computers. In this chapter, we use the term

'virtual agent' to refer to a virtual entity with some autonomous decision making capabilities. Virtual agents can be broadly categorised as being 'authorable' or 'autonomous', with authorable agents requiring someone to observe the user and select from a control panel actions for the agent to take, much like a virtual puppet, and autonomous agents being self-contained and usable without such outside interaction. Examples of both authorable and autonomous agents are discussed in Section 2.2.

2.1 Virtual tutors and why they can benefit children with autism

ECAs are used in a range of applications. When used in an educational context, they are often referred to as virtual tutors or pedagogical agents. There are a multitude of reasons why virtual tutors are well suited to use with individuals with autism, including the affinity that many report having with technology (Putnam & Chong, 2008). A technology based intervention for improving social competence appeals to children with autism and allows them to progress through material at their own pace rather than being subjected to the constraints of a classroom. Nothing should aim to replace interaction with peers and others when learning about social interaction, however, an independent learning tool, such as one including a virtual tutor, can be a valuable tool in developing these complex social skills.

Autonomous virtual tutors can complement other interventions and allow learners to practice their developing skills independently, reducing pressure on those who work with the student and allowing them to focus on more complex aspects of the learner's education, while general topics are covered by the software. The anxiety connected with interacting with real humans is absent when using a virtual tutor, which can be programmed to ensure that only positive and guiding feedback is provided, rather than the criticism that peers may give. Additionally, using a virtual tutor means that the learner can practice their skills without interfering with others or learning inappropriate responses from incidental people in the environment (Kerr, 2002). Another advantage is that the virtual tutor will never get tired or impatient (Massaro, 2004) and it is available for practice at any time of the day, which may particularly suit those who experience abnormal sleep patterns (Limoges et al., 2005). Virtual tutors provide consistent feedback and behaviours, again helping to control anxiety in sufferers who feel more at ease in predictable situations (Parsons et al., 2000).

Virtual tutors can be highly customizable, allowing them to be tailored to suit an individual learner's needs. For example, for a learner who finds looking at faces uncomfortable, the tutor's face could start out cartoon-like and, as the learner becomes accustomed to it and their confidence grows, the complexity can be increased. Likewise, the lesson content can be modified to meet the learner's current level of interest and need. Being software-based, a variety of media can be incorporated into the learning material, for example photos, videos, animations and more, which can help to support generalisation of skills to novel situations.

In the context of developing nonverbal skills, animated virtual tutors can be particularly useful as they can model behaviours for the learner, such as facial expressions and gaze. This is akin to video modelling, which has had success with many individuals with autism (Marcus & Wilder, 2009; Sherer et al., 2001). Multiple tutor 'personas', with differing appearances and voices, can be used to model the behaviours, encouraging generalisation to novel situations. The flexibility and customisation that virtual tutors offer makes them a cost effective and potentially highly beneficial intervention tool.

2.2 Examples of existing virtual tutors

Several virtual tutors have been developed for a variety of educational applications, some with embodied agents. Two well-known examples that do not incorporate an embodied agent are Project LISTEN (Mostow, 2005), a reading tutor aimed at neurotypical primary school students and Carnegie Mellon's Cognitive Tutor (Ritter et al., 2007), aimed at neurotypical secondary school students who are low-achieving in mathematics. Virtual tutors with embodied agents include Wayang Outpost (Woolf et al., 2010) and iSTART (McNamara et al., 2004), which both have multiple agents and target neurotypical secondary school students, Wayang Outpost focussing on mathematics and iSTART on reading comprehension. All of these tutors are autonomous and have been empirically evaluated with very positive results; however, none were designed for or evaluated with learners with autism and all deal with domain knowledge where questions have clear-cut correct answers. Two examples of ECA tutors for children with autism are Baldi (Bosseler & Massaro., 2003), an autonomous agent originally designed to increase the vocabulary of hearing-impaired children but found to be highly successful in trials with children with autism, and Sam (Tartaro & Cassell., 2008) a virtual peer used to improve social interaction skills, including turn-taking and gaze behaviour. Unlike the previous tutors, Sam is an authorable agent and requires a researcher or the learner to select behaviours to display via a control panel. Results of the evaluations of both Sam and Baldi were positive, particularly exciting being that both interventions resulted in skills generalising to novel contexts. A month after the intervention with the embodied agent, children were still using their newly acquired vocabulary in everyday situations (Bosseler & Massaro., 2003). After interaction with Sam, children improved their scores on the Test of Early Language Development and displayed increased social behaviours, such as improved gaze (Tartaro & Cassell., 2008). The results from these evaluations are very encouraging, and it is hoped that an autonomous social skills tutor aimed at children with autism will likewise lead to improved social outcomes.

3. Teaching methods

When developing a virtual tutor, it is imperative that the teaching methods employed are carefully selected to best support the target group in achieving success with the content being taught. To make an informed decision regarding teaching social skills through software, we must first understand what methods are typically used to teach social skills and what can be achieved in a software context. In this section, a range of approaches are briefly addressed including those used by human educators and those used in software.

3.1 Approaches used by human educators for learners with autism

A range of approaches are available for teaching children with autism, and typically a variety of methods will be used. Here, focus is given to approaches with established effectiveness in addressing the needs of children with autism including the techniques of direct teaching, modelling, scenario-based learning and role playing, tutoring, exploratory and naturalistic play, conceptual mapping, and reflective practice.

3.1.1 Direct teaching

Learners with autism have difficulty learning from experience and typically need new ideas specifically taught to them. In contrast to student-directed approaches, direct teaching involves explicitly teaching skills and knowledge to learners and providing

reinforcement for desired responses. Taking such a direct approach is often effective for this learner group.

Applied Behaviour Analysis (ABA) is one of the best known techniques for altering behaviours in children with autism. Developed in the 1960s by Ivar Lovaas, ABA involves a therapist providing direct consequences for behaviours, for example providing toys or food that the learner finds reinforcing when desirable behaviours occur (for details see Keenan et al., 2005). There are a number of shortcomings to this approach, one being the time consuming nature of it. It also requires trained professionals, which becomes very expensive over multiple sessions, and requires the child to interact socially in an intense fashion which can be confronting, at least initially (Hailpern, 2007). Many similar programs have been developed and the core principles of prompting and positive reinforcement are widely used in a range of settings (Reichow & Volkmar, 2010). While the ABA approach is effective for many and is widely used, there are now options available that gently prepare the child for intense social interaction before exposing them to it in all its complexity.

Another commonly used program is the Treatment and Education of Autistic and Communication Handicapped Children (TEACCH) program. Panerai et al. (2002) investigated the effectiveness of the TEACCH program as compared to a control group who were in typical classrooms with support teachers. They found that students in the experimental group made significant gains across the duration of the evaluation. TEACCH provides continuous, structured intervention, has a strong focus on the use of visual aids to make abstract concepts more concrete and provides for environmental adaptation and training in alternative communication (for more information see Panerai et al., 2002). As autism is a pervasive disorder, TEACCH is designed to be used in all aspects of the learner's life, not just school activities. The use of visual aids, adaptations in the learner's environment and the focus on providing methods of communication are all important general principles for educating children with autism.

One theory that attempts to explain some of the social difficulties that children with autism encounter suggests that they lack a fully developed 'Theory of Mind' (Leslie, 1987). This means they struggle to understand that other people have separate thoughts and feelings to their own. Carol Gray's Social Stories™, Comic Strip Conversations and the thought bubble approach used by Wellman et al. (2002) aim to address this deficit. Social Stories™ are instructional stories that explain to the learner how to behave in particular social situations. They are written following a set of guidelines developed by Carol Gray, that state that sentences should be short and explicit and accompanied by simple, informative images that support understanding. Social Stories™ are very visual and provide explicit instructions specific to the situation, suiting the common learning style of children with autism. Several studies found significant improvements to social behaviours from using Social Stories™ (Quirmbach et al., 2008; Sansosti & Powell-Smith, 2008), while other studies suggest that the effectiveness of a Social Story™ is reliant on a variety of factors, including the quality of the story itself and the behaviour it is targeting (Lorimer et al., 2002; Reynhout & Carter 2006). Carol Gray has also developed Comic Strip Conversations, which are developed following similar rules to the stories, but in comic strip format. The use of these comic strips has led to similarly positive results. Wellman et al. (2002) also use a pictorial approach, but start with concrete objects and gradually work towards abstract images. Initially, Wellman et al. (2002) used dolls with cardboard thought bubbles above their heads and gradually reduced the concrete supports until images alone were sufficient for the learners. In all of these

approaches focus is given to providing visual supports along with clear and concise step-by-step information, as suits the typical learning style of individuals with autism. The same guidelines can be incorporated into software developed for this user group, whenever visual, written or spoken information is presented.

3.1.2 Modelling, scenarios and role playing

Many people, those with autism included, learn better by performing a skill than they do only reading or hearing about it. Modelling desired behaviours and then having learners act them out in artificial but sufficiently natural scenarios can be highly beneficial in assisting them to perform the targeted behaviours in real situations.

The Social Use of Language Program (SULP) approach is used with small groups of students. Initially, a story addressing the target behaviour is shared, similar to the Social Stories™ approach discussed earlier. Next, adults model the desired behaviours for learners to observe before they practice the behaviours themselves and play games with their group that facilitate skills practice. Finally, activities are performed in new situations to encourage generalisation. Children who undertook the SULP intervention made significant improvements in comparison to the control group (Owens et al., 2008).

Video modelling is a technique where the learner is shown a video of themselves or a peer performing a skill that they are intended to acquire. Video modelling has many advantages. Minimal expertise and expense is required to implement the intervention, it is repeatable, it can be conducted in a standardised manner and it is portable. A recent review into best practices for social skills interventions found numerous studies supporting the effectiveness of video modelling, but suggest that video modelling alone may not be sufficient to maintain long term behavioural changes (Reichow & Volkmar, 2010). Marcus and Wilder (2009) compared the effectiveness of self-video modelling and peer-video modelling with three children with autism and found that in the self-modelling condition, all participants reached the mastery condition whereas only one did in the peer-modelling condition. Anecdotally, the authors reported that children enjoyed the self videos more and wanted to watch them even after the study was concluded. However, this study involved a text based task, not a socially oriented one. Sherer et al. (2001) compared self and video modelling for teaching conversation skills to five children and found no significant difference between the two, with some learners performing better in one condition and some in the other. Thus it seems that video modelling is an effective teaching tool, but as with most approaches, should be optimised to suit the individual learner.

3.1.3 Tutoring

One-on-one tutoring has been found to produce greater conceptual understanding and a higher level of motivation in students than traditional classroom situations, with students even progressing through topic content at a faster rate. The average performance of students when working individually with a tutor was found to be up to 2.3 standard deviations above that of students in a typical classroom situation (Chi et al., 2001; Graesser et al., 1999), providing strong evidence for the benefits that a personal tutor can provide a student.

Human tutors typically follow a set pattern. First, the tutor asks a question, to which the student provides an answer. The tutor provides immediate feedback and performs scaffolding across a number of turns with the student in order to help the learner develop their understanding. It is this process that is thought to contribute most to the increased

benefits of tutoring over traditional classroom situations. Finally the tutor assesses the learner's comprehension of the taught content (Chi et al., 2001). Scaffolding is an essential aspect to learning, particularly for individuals with autism who need concepts to be explicitly taught. Scaffolding involves breaking down concepts and procedures into smaller, more manageable tasks (Jackson et al., 2010). Tutors encourage learning by helping students to master these small tasks, gradually working towards the final goal. Throughout this process the tutor monitors the learner for confusion and frustration and provides assistance where needed. This is critical as deeper and more rapid learning is achieved when misunderstandings are addressed immediately (Chi et al., 2001; Kerr, 2002; Silver & Oakes, 2001). As opposed to a classroom setting, where the learner often passively receives information from a teacher addressing the entire class simultaneously, tutoring encourages students to interact with their new knowledge through predicting, justifying, criticising and otherwise engaging with the material (Chi et al., 2001). Scaffolding is an essential educational technique that can also be implemented via a virtual tutor.

3.1.4 Explorative and naturalistic play

Less structured, naturalistic approaches that utilise innately motivating and reinforcing everyday activities and materials have been shown to support generalisation of skills in children with autism. However, care must be taken when using exploratory approaches. While they facilitate students with existing skills to expand their knowledge by encouraging them to engage in observational and experiential learning, as well as trial and error, they are typically less effective with lower skilled learners who need more structure (Conati, 2002). It is expected that learners with autism will often need more structure, due to their preference for sameness and difficulty learning without explicit explanations.

LEGO™ therapy is one example of a successful play-based therapy for children with autism. In LEGO therapy, children in small groups are given roles and must work together to build a LEGO construction. The group can also include neurotypical peers and adults. The construction task provides group members with an opportunity to practice many social behaviours including joint attention, verbal and nonverbal communication, collaboration and problem solving skills. LEGO is predictable and systematic, catering for the preference for consistency many learners with autism display. A study by Owens et al. (2008) contrasted two peer group therapies for 6-11 year olds, LEGO therapy and SULP (discussed earlier). It was found that the children in both groups outperformed the control group and those in LEGO therapy outperformed those in SULP. The researchers note that the two therapies may be best for different sets of social skills, with more research required. However, this is a good example of how naturalistic play, when guided to encourage social skills, can improve the social behaviours of children with autism.

3.1.5 Conceptual mapping

Existing work has shown that drawn and written graphic organisers, such as concept maps, can lead to strong learning gains in children with high functioning autism (Roberts & Joiner, 2007) and when used in conjunction with peer group instruction, can lead to improvements in social skills (Laushey et al., 2009). Concept maps are graphical representations of concepts, typically consisting of labelled nodes interconnected by directional arrows representing the relationships between the nodes. These are very visual and thus make clear otherwise abstract ideas and the connections between these ideas. Existing research by

Kinchin et al. (2000) suggests that concept mapping allows us to discover what students really know and how their knowledge is interconnected, rather than trying to make judgements and informed guesses. It also helps to emphasise the importance of synthesising and integrating ideas and concepts, rather than simply repeating isolated facts and expecting students to make meaning from this. It is hoped that by using concept mapping to teach social skills, it will help students understand the cause and effect relationships connected to our behaviours, rather than just being taught rigid rules, and will therefore help them apply their skills in novel situations.

3.1.6 Reflective practice

Meyer and Land (2010) recommend the use of speak aloud self-explanations, where the learner describes the ideas they are learning in their own words, as a reflective practice to enhance learning. Meta-cognitive skills and reflective practice such as this have been demonstrated to lead to better problem solving skills and the construction of deeper, more meaningful conceptual connections as they encourage students to consider the processes they use when learning instead of focussing only on the content itself (Mitrovic, 2001). Black and William (2009) also emphasise the importance of reflective practice for deep and long term learning. They suggest that reflection can assist students to make the processes they use unconsciously explicit and concrete, making them easier to understand and implement in future. It is suggested that discussion with peers and others improves the outcomes of reflective practice, in following with Vygotsky's principle that ideas are initially constructed in social interactions, and then internalised by the learner (Black & William, 2009). Additionally, challenging students to identify other situations where they can use the same thinking processes, to compare and contrast ideas and to critically analyse them can help learners improve their problem-solving and cognitive skills in general and to apply their skills to other areas.

3.2 Approaches used by virtual educators

Tartaro and Cassell (2006) and Silver and Oakes (2001) provide guidelines specifically for developing software for individuals with autism, derived from their own experiences doing so. One of the key points is the importance of scaffolding, which as we have already seen is an important general educational consideration. Herrera et al. (2008) developed a virtual environment that used an explicit scaffolding approach to gradually take children from functional interaction to imaginative play. In this manner, abstract ideas can be made concrete. Use of this software led to improved skills and evidence of generalisation. In the following sections key educational approaches taken in virtual tutoring software are briefly discussed, including static and dynamically sequenced activities, explorative activities, teaching a virtual peer, conceptual mapping and reflective practices.

3.2.1 Statically sequenced activities

Human teachers are capable of adapting their lesson sequences on the fly. This is a challenging task for a computer and so many software tutors present the learner with a set sequence of tasks. Such an approach can still lead to positive outcomes, as evidenced by The Junior Detective game (Beaumont & Sofronoff, 2008). This software was evaluated as part of a social skills group therapy program, where students were also given opportunities to role play the skills taught. This combination led to significant improvements in participants'

social skills and their ability to suggest strategies to manage emotions. In a follow up session months later, participants maintained their skills (Beaumont & Sofronoff, 2008). Emotion Trainer is software designed to improve facial expression recognition in learners (Silver and Oakes 2001). It simply presents scenarios and photos as a multiple choice quiz, repeating the same section until the learner gets a certain number correct. Emotion Trainer was evaluated in a randomised control trial with eleven pairs of children with autism. One child in each pair used the software. All children who used the software improved their skills to varying degrees. Additionally, children were able to generalise their skills to a similar paper based task, but their ability to apply their skills to real social situations was not investigated (Silver & Oakes, 2001). These examples demonstrate how software, even with a static activity sequence, can be used as a step in the scaffolding process that leads to the development and maintenance of sophisticated social behaviours and problem solving skills.

Another example of statically sequenced educational software leading to positive outcomes is the social skills virtual tutor developed and evaluated in the pilot study by Milne et al. (2010). Two modules were developed, both with significant positive outcomes. In the module addressing strategies for dealing with bullying participants exhibited an average improvement of 54% from pre- to post-testing and in the conversation skills module improved on average 32%. Participants reported the experience to be an overall positive and non-threatening way to improve their social competence. Future plans for this tutor are to implement automated assessment to facilitate dynamic sequencing of learning activities.

3.2.2 Dynamically sequenced activities

To tailor experiences and activities to suit individual learning styles, a student model for the individual is required (Wittwer et al., 2010). A number of factors influence a students' learning style at a given moment, including their pre-existing preferences (for example children with high-functioning autism tend to be very visual learners) and their level of experience with the current concept. It has been shown that inexperienced and experienced learners display different styles, with inexperienced learners gaining more from following worked examples and experienced learners benefitting more from solving problems (Wittwer et al., 2010). Automated software that can determine and implement a favourable method of instruction for the student's current situation, as human educators naturally do, would be a valuable component for an autonomous tutoring system.

Shute and Towle (2003) present a generic framework for intelligent tutoring systems that takes into account individual learner differences, the learner's current state of knowledge and best practices for instruction. It is based on aptitude-treatment interaction (ATI) research, which uses a range of learner profiles to predict the user's needs and allow for lesson content and presentation to be adapted appropriately. Content presentation can range from step-by-step, highly structured instruction to exploratory presentation where the student has much control over the lesson sequence. Shute and Towle (2003) propose the use of small, self-contained and reusable components that can be combined into lesson sequences. Each unit should be limited to one of the three types of knowledge: basic knowledge (such as facts or formulas), procedural knowledge or conceptual knowledge. Sets that teach a single skill or idea can then be defined, with relationships between units influencing the sequence that tasks are presented in. This framework provides the flexibility required for a social skills tutor given the diverse range of user needs.

In the development of the Carnegie Mellon Cognitive Tutor, the Adaptive Control of Thought - Rational (ACT-R) theory of human cognition was central to its design (Anderson,

1990). The ACT-R theory, one of the more strongly supported and well established theories of human cognition, suggests that for educational materials to be most effective they must present concepts along with procedures, allowing students to understand what they are doing and why, new knowledge must build upon existing knowledge so that stronger and longer lasting connections can be made, students must be presented with a variety of opportunities to learn and practice their skills, and students' knowledge must be assessed regularly to ensure that the educational materials presented are focussing on what the individual needs, rather than providing unnecessary instruction in areas where the student is already proficient (Ritter et al., 2007). Thus, the ACT-R theory emphasises the importance of students building conceptual knowledge and cognitive skills, not just procedural skills and disconnected facts, and provides a framework to achieve this.

3.2.3 Explorative activities

Crystal Island and Gaining Face are examples of software designed to teach through a primarily explorative approach, where learners work through the software at their own pace without any goals being set explicitly by the program (Robison et al., 2009). Gaining Face provides learners with resources that they can use to investigate which nonverbal cues match with which emotions. Both detailed written information and diagrams are presented, and learners are able to compare two emotions at once. It also has an inbuilt self-test and covers a wide range of facial expressions. Crystal Island is a narrative-based learning environment that encourages self-reflection. Users explore the game environment and when they interact with game characters, they are prompted to self-report their affective state. This information is used to inform what feedback the user is given. More research is needed to evaluate the effectiveness of using an explorative approach in educational software.

3.2.4 Teaching a virtual peer

A recent approach that is gaining interest is that of a teachable agent, where the student teaches the agent as a means of learning new concepts themselves. This idea is motivated by the observation that many teachers find they have a better understanding of a concept or skill after they have taught it. In this scenario, the student takes responsibility for their own learning, a valuable life skill, and tests their understanding by trying to pass on their knowledge to a virtual agent. Betty's Brain is an example of such an agent (Blair et al., 2007). Using a concept map interface, students teach Betty concepts by adding nodes and connections between the nodes. Betty can then answer questions using the concept map and can tell students when she detects missing information. Betty's Brain has been incorporated into a number of appealing video game fronts, including a quiz where students put their virtual agents against one another to see which has learnt the concepts most thoroughly. The Betty's Brain system was tested with fifth grade students on a task requiring them to develop concept maps about river ecosystems and eight weeks later used the same systems but applied to a new topic, the land-based nitrogen cycle. Three versions of Betty's Brain were tested, one in which students taught the system, one in which they taught the system and received prompts from Betty and one in which they built a concept map for themselves but with coaching from the system. It was found that students in the first two conditions performed better than in the last, providing evidence that learning by teaching is a valuable technique (Biswas et al., 2009).

3.2.5 Conceptual mapping

Conceptual mapping, as mentioned earlier, is a beneficial and well-supported educational tool. Meyer and Land (2010) recommend conceptual mapping as a method of making

misunderstandings and barriers to knowledge observable and hence manageable for educators. Many software systems exist for building concept maps, an example being Kidspiration (Inspiration Software, 2011). As a learning and formative assessment tool, concept maps can be created collaboratively between peers or the learner and educator. In software, a virtual tutor may assist the student by adding a node or reversing the direction of a connection that the student has placed. Concept maps are particularly applicable to autonomous tutoring software as, when structured appropriately, they can be automatically assessed and are valuable for use with children with autism as they are highly visual.

3.2.6 Reflective practice

As discussed earlier, reflective practice is a valuable tool that leads to richer educational outcomes and can be readily facilitated in a software context. Mitrovic (2001) conducted a study with university level computer science students to evaluate their self-assessment capabilities. Students used SQL-tutor, an application for practicing programming in the SQL database language. If students abandon a problem before completion, they are asked to specify a reason why – too hard, too easy or want a different type of question. It was found that more able students displayed better understanding of their own educational needs, rarely abandoning questions, and typically selecting wanting a different type of question as the reason when they did. Less able students abandoned many more questions, often citing that the problem was too easy even when evidence suggested otherwise. This suggests that a system that visualises interaction history and perhaps prompts students to more carefully consider the reasons for their difficulties may help to nurture meta-cognitive skills and improve educational outcomes. It has also been found that discussion with peers nurtures reflective practice, as the learner must justify and clarify their own understanding. This may appear impossible with individually-used social tutoring software, however, a possibility is to have the virtual agent play the role of a peer and activate these same learning benefits.

4. Assessment methods

Assessment is a broad term and can include assessing a student's learning style or their level of motivation. While these are relevant areas to investigate, here we focus on assessing content mastery. While many people automatically think of an "end of topic" test as a key assessment task, it is important to understand that assessment serves several purposes and must be conducted at multiple points throughout the learning process. Black and William (2009) emphasise the need for ongoing assessment, as it provides three key functions: establishing what students already know, what they need to know and determining what to do to reach these goals. If this is done regularly, the educational process is managed so that misunderstandings, repetition of already mastered content and other difficulties are minimised. To accurately assess a student's needs, the reason behind their difficulty must be determined. This could be a range of reasons, including misunderstanding the language used, the purpose of the task or the task itself, being misled by an unimportant element of the task, using ineffective strategies or simply not providing a clear or sufficiently detailed response (Black & William, 2009). It is also possible that the student does in fact have the targeted skills or knowledge mastered, but simply misunderstood what was required of them. Thus, ongoing assessment conducted in a manner that allows for effective analysis of student needs is essential for effective teaching and learning. In the context of developing a virtual social skills tutor for children with autism, ideas from two key areas must be synthesised: assessment of social skills and computer automated assessment techniques.

4.1 Assessment of social skills

There are a range of techniques used by therapists, teachers and others to assess the social skills of children, both neurotypical and those on the autistic spectrum. Here we provide a brief overview of techniques that can potentially be integrated into a virtual tutoring context, including observations, interviews, self-reports, checklists and scales.

4.1.1 Observations

Observations, both in real-time and from pre-recorded video, are often used when assessing social competency of children with autism. This is typically combined with a checklist or other rigorous method of systematically recording children's behaviours. Unfortunately, assessment through observing real social situations is not a viable technique in a computer based system intended for independent use and thus determining whether an issue reflects an underlying skill deficit or performance deficit is difficult. Having the learner interact with virtual humans in role play situations and recording learner behaviours in these situations may help to determine such differences. Another way of potentially integrating observations into a software program would be to provide a mechanism through which adults working with the learner can input their observations into the software system.

4.1.2 Interviews and self-reports

Sansosti (2010) recommends interviews as a useful assessment tool able to provide a picture of the student's needs and states that asking parents, teachers and the student themselves about the learner's typical behaviours and antecedents to desirable and undesirable behaviours will give the best overall indication of a learner's social competence. Interviews are difficult to reliably conduct in a natural, open-ended way in software; however, asking a question and allowing the interviewee to respond using multiple choice check boxes or sliding scales may be a viable option. Such a technique could also be used for self-reporting by the student, however care must be taken when using self-reports for judging social competency, as discrepancies can exist between what a student knows they should do and what they actually do. It can also be a challenge to determine whether a difficulty stems from a skills deficit or a performance deficit, however, the distinction impacts strongly on the educational tasks required to overcome the difficulty (Bellack, 1983). Carefully constructed and clearly worded questions can provide a valuable starting point for social skills education and are simple to implement in software.

4.1.3 Checklists and scales

A number of established social skills assessment tools exist, however, currently there is no one tool that is universally preferred and so only a small sample is discussed here (Gresham et al., 2010). Two examples of existing scales are the Matson Evaluation of Social Skills with Youngsters (MESSY) and the Social Skills Rating System (SSRS) (Wilkins, 2010). In both MESSY and SSRS, evaluation items are presented in Likert-style scale and forms exist for the individual, parent and teachers to respond. This process can be automated and thus incorporated into an autonomous social tutor. MESSY and SSRS are valid for use with school age children. MESSY has sound psychometric properties and has been validated for use with individuals with autism, whereas the SSRS was designed for use with neurotypical children, thus the MESSY assessment tool appears preferable for implementation in tutoring software for children with autism (Wilkins, 2010; Williams White et al., 2007).

The Behavioural Assessment of Social Interaction in Young Children (BASYC) is a recently developed tool that may be useful for high level assessment in a social tutoring application, as it is designed for teachers to administer and thus does not require psychology training, and can be used for goal planning and progress monitoring (Gillis et al., 2010). The BASYC provides a list of interactions as a guide and a checklist of behaviours, so the influence of examiner subjectivity is minimised and the task of automating assessment is simplified. The BASYC requires behavioural observation in a naturalistic, semi-structured setting so it remains to be seen whether adaptation to a software context is viable.

Measuring social competence by observing displayed behaviours has been suggested as insufficient and assessing social problem-solving and critical thinking skills, identification of a key idea and interpretation of abstract language may in fact give a better indication of a learner's social competence (Garcia Winner, 2002). The development of an assessment tool that is reliable, valid, appropriately sensitive to change, and reflects the learner's overall performance is still an active research area in itself (Gresham et al., 2010).

4.2 Computer automated assessment

Common computerised methods of evaluating concept mastery, for example achieving a particular percentage or a certain number of consecutive assessment tasks correct, are generally insufficient for providing a realistic picture of student understanding (Shute & Towle, 2003). Traditional approaches with closed-end answers, for example multiple choice questions and fill in the blanks, do not allow the learner to adequately demonstrate their knowledge. In many cases a learner can explain what behaviours are expected of them, but fail to demonstrate these behaviours in the situations we intend them to be performed in. Thus, more sophisticated methods of computer automated assessment are required.

4.2.1 Approaches based on psychology research

Sehaba et al. (2005) developed a system for use with lower functioning children with autism, to assist them to develop their motor skills and spatial and temporal understanding. The system continually collects information about user interactions with the system, including keyboard input, mouse actions and camera feed, and uses this to understand the child's behaviour and respond to it in real time. The system consists of a number of agent modules with differing roles. The User Observation Agent (UOA) records and associates user actions with terms that characterise the behaviour, notifies other agent modules when required and controls access to system resources. The UOA was inspired by the Theory of Affordances and Theory of Procedural Semantics. The Tutor Agent selects the current teaching strategy based on its knowledge of the user needs and profile, which includes preferences, general information, history and domain knowledge. It stores experiences and updates the user history and profile where applicable, making the overall system adaptable to individual needs. The Exceptions Management Agent (EMA) monitors interactions between the system and the user and makes modifications when it detects special cases needing unique treatment, for example with avoidance behaviour the EMA can intervene to engage the user again. The software employs a memory system based on Schank's Dynamic Memory Model, where Generalised Episodes are extracted from similar events, allowing for past episodes applicable to the current one to be rapidly found. System behaviours are determined using case-based reasoning, where past solutions and behaviours are applied to current ones. Preliminary evaluation of the system is said to be promising (Sehaba et al., 2005).

Gao and Xu (2007) also developed a model for assessing student needs and delivering applicable content based on Herbert A. Simon's classic decision-making process model. The four stages of the model are the intelligence stage, where information is gathered and the problem identified, the design stage where success criteria and alternative solutions are proposed, the choice stage where the best alternative is chosen and the review stage where the outcome is analysed. The review stage can help influence the intelligence stage for future decisions, improving outcomes over time and ensuring the system is adaptable. The system developed is similar to that of Sehaba et al. (2005) and is a prototype.

4.2.2 Probabilistic approaches

Probabilistic approaches can be used to identify gaps or misunderstandings in learners' knowledge that would not necessarily be found using traditional approaches to computerised assessment, while providing flexibility for dealing with the variety of answers students can provide. Shute and Towle (2003) recommend the use of Bayesian inference networks (BINs) or student mental modelling to provide probabilistic values which can be used to identify such issues within learners' knowledge. Martin and VanLehn (1995) implemented a Bayesian network approach to assess student understanding of university level physics. The network takes student behaviours as input and calculates the probability that they know and are using the appropriate rule for the given question. Bayesian networks allow for the system's hypotheses about student knowledge to be ranked rather than just classified, providing a flexible approach to assessment and better informing the sequence of tasks presented to the student.

Conati (2002) proposes a method for implementing a decision-theoretic agent, that is, one where the agent makes decisions based on maximising the likelihood of a desired outcome. In the decision-theoretic model, world states are assigned a value indicating their desirability and agents provide a value indicating their belief that the particular state will lead to the desired outcome. Using this information, actions are selected with the aim of bringing the system closer to the desired goal. Conati (2002) suggests using Decision Networks (DNs), an extension of Bayesian Networks allowing for this behaviour. By combining DN with the Five Factor Model of Personality and the OCC model of emotion and cognition, predictions about the user's emotional state can also be made (Ortony, Clore and Collins, 1988). The OCC model explains that emotional reactions are the result of the desirability of a given outcome, the desirability being influenced by the goals and preferences of the user. Thus, if the user goals and preferences can be determined, the OCC theory provides a clear basis for predicting emotional outcomes and thus allows the agent to manage and adapt to situations taking user emotions into account. Negative emotional states are not conducive to learning and it is the job of the tutor to guide learners through these states and into a positive affective state, as human teachers do (Kort et al., 2001)

4.2.3 Latent semantic analysis

In autonomous tutoring applications, a common approach to judging student knowledge is to use latent semantic analysis (LSA) to judge the semantic similarity of student responses to a provided 'ideal' response. This is the approach taken in the iSTART tutoring system discussed earlier (Jackson et al., 2010). LSA is used for higher-level assessment and provides a judgement about the student's overall understanding. Hu and Xia (2010) also use latent semantic techniques in their automated assessment system, first performing pre-processing of student answers to generate a document of relevant words then comparing this to the

similarly processed expected response. Hu and Xia (2010) found no significant difference between the grades provided by their system and those provided by teachers, suggesting that this is an educationally valid technique. Latent semantic techniques such as these rely on comparisons between blocks of text; however, as autism is partly characterised by impairment in communication and language skills, it is unreasonable to expect these children using the system to be able to provide sufficient written responses for LSA techniques to be applicable. While some form of statistical similarity measures may be applicable for assessment in this context, it will be dependent on the tasks presented.

4.2.4 Conceptual mapping

Concept mapping is a beneficial training tools that can be used for both summative and formative assessment purposes. A number of concept map types exist, and the type used should be considered carefully in relation to the desired outcome, as no dominant or recommended method currently exists (Park & Calvo, 2008). Spontaneous maps can be challenging to automatically assess, as students are free to use any terms and interconnections they wish, however, the richness of assessment is immense, with map hierarchy indicating knowledge depth (Kinchin et al., 2000; Park & Calvo 2008). One of the simplest concept maps to assess is the "fill in the blanks" style map and if terms to fit the blanks are provided, the task of assessment is simplified even further (Cline et al., 2010; Park & Calvo 2008). Concept map styles can fit anywhere between these two extremes, however, care must be taken in structuring the concept map appropriately to ensure outcomes are representative of actual knowledge and not just 'good guessing' and yet assessable in a consistent and valid way. Depending on the map type, measures may include raw and weighted counts of connections, node and proposition matching and the proportion of valid student connections over total or student-made connections (Park & Calvo 2008).

Cline et al. (2010) developed an automated system for constructing and assessing concept maps known as the Concept Mapping Tool (CMT). The CMT is a web-based tool that allows teachers to build criterion concept maps and for students to build their own maps, in the form of directed graphs, which are then compared to produce a grade. CMT uses a rule-based evaluation system to compare the nodes, direction of connections between nodes and other aspects of the map to determine a final grade. The system provides students with immediate feedback, which has been repeatedly demonstrated to be beneficial to the learning process (Cline et al., 2010). Students are presented with the central concept, concept nodes and distractor nodes based on the criterion map provided by the teacher, and are required to use these to demonstrate their knowledge by providing connections between appropriate concept nodes. This is highly structured, as students cannot provide their own terms for concepts, however, it is also flexible as distractor nodes are present and no hints are given regarding the connections between the concept nodes.

To increase the flexibility of this approach and allow students to provide their own terms, it is suggested that CMT and similar programs could be integrated with online thesauri and tools such as WordNet (Harrison et al., 2004). However, great care must be taken to maintain the correct meaning when using synonyms as many words have multiple meanings with subtle differences. This approach is taken in the automated concept map assessment program Robograder, developed by Luckie et al. (2004), and further research is looking at marking maps in a holistic manner as many human markers do. The validity of the holistic approach is questionable, as existing educational research has shown that using a rational approach when assessing concept maps provides more consistent and accurate

results than holistic approaches (Cline et al., 2010). When map structure and assessment approach are carefully selected, concept mapping techniques can provide strong educational benefits to learners while being reliably and rapidly automatically assessed.

4.2.5 Scenario-based techniques

Scenario-based techniques are valuable training tools that can also be used for assessment purposes. These involve the learner working through a fictional scenario. Periodically, the system presents the student with a situation within the scenario, for which the learner selects the response they would take, and the system then informs them of the consequences of their choice. The Pedagogical Psychology Computer Assisted Assessment project (PePCAA) developed a computer automated tool to assess trainee teachers' pedagogical knowledge (Crisp & Ward, 2008). Trainee teachers were presented with scenarios based on realistic classroom situations and required to apply their problem solving skills and knowledge of best practice. The scenarios had multiple steps, with subsequent questions being based on the trainee's earlier choices. Trainees were asked to give a confidence rating and to justify their choices. Feedback for open ended tasks involved presenting the trainee with a list of points that should have been included and asking them to select which ones were covered in their answer. This scenario-based technique is constrained enough to be analysed by a computer, while providing deeper insight into learners' understanding than most traditional methods could.

In evaluation of the 'Fear Not!' software, designed to teach users how to constructively deal with bullying, Hall et al. (2009) evaluated neurotypical children's social awareness through Theory of Mind (ToM) questions. Children were presented with bullying scenarios acted by virtual characters and were asked by the 'victim' character for advice. At the conclusion of the program, children were asked to judge how different characters felt at various points throughout the story. The questions required learners to make judgements about mental states, emotions and intentions of the characters. Students were asked a combination of short-answer and multiple choice style questions, which were accompanied by visual prompts to help them remember the role-play. Hall et al. (2009) found this technique provided valuable insight into the children's social awareness of the presented situations; however, application of this insight was not discussed. Assessing social awareness is a challenge as even socially competent adults often disagree on the interpretation of a social situation, thus there is often no definite distinction between 'right' and 'wrong', with answers falling on a continuum of acceptability.

Jarrold (2007) attempts to address the problem of judging whether a learner's social assessment is valid or not in comparison to neurotypical adults' assessments by analysing adult responses and developing a rule-based system that can make judgements on par with humans. The system must allow for a wide variety of plausible social judgements, while still being able to identify inappropriate responses. This system will be used to generate Theory of Mind style questions commonly used with learners with autism. To achieve this goal, three related studies were performed. In the first study a small set of items from Teaching Children with Autism How to Mind Read (Howlin et al., 1998) were selected and neurotypical adults asked to provide responses, as is done for children with autism when judging their ToM skills. The responses were used to inform a model of adult inferences. The second study validated the outcome of the first, by asking raters to assess the believability of statements generated using the new model. The third study used data from

the previous two to build a model and expert system that includes background knowledge about the world, allowing for a wider range of realistic scenarios to be generated. The expert system uses general goals and rules that can be applied to many situations, and was found to perform almost as well as humans in creating affective evaluations. Such a tool would be very valuable in both generating scenarios for learning and for assessing responses given by students in an autonomous tutoring application, as it is both flexible and automated.

5. Developing an ECA for social skills teaching

All learners have varying preferences and needs, so it is unlikely that a static, one-size-fits-all approach can be taken in any educational program. In an ECA-based social skills tutor, the ability to adapt to the learner's needs, coupled with a range of customisation capabilities, is desirable. In the existing work by Milne et al. (2010) a highly customisable ECA, Head X (Luerssen et al., 2011), is at the heart of the autonomous social skills tutoring software. This ECA can be readily customised to have varying appearances, voices and facial expressions, and work is being conducted to allow parents, teachers and others to create their own lesson units and to easily modify existing ones, for example replacing the images provided with images that the particular learner finds more stimulating or understands better. It is believed that ECA methods will offer caregivers and educators an engaging and worthwhile educational tool that can be applied to a wide range of learning requirements.

5.1 Developing software for users with autism

When designing for a particular group the traits and needs particular to that group must be thoughtfully catered for. For software users with autism, communication challenges and sensory challenges are particularly important to take into consideration, as is the need to support generalisation of skills to other contexts.

5.1.1 Sensory challenges

Sensory tolerance can be a significant issue for some individuals with autism. To minimise the risk of sensory overload, it is advisable to omit unnecessary visual or aural material. In practical terms, this means avoiding animations and sound effects unless they add significant educational value. This simplifies the interface and avoids causing distraction or fixation (Davis et al., 2005). Some sufferers have low tactile tolerance, making mouse and keyboard use challenging, while others have low aural tolerance, making speech-recognition and text-to-speech interfaces confronting (American Psychiatric Association, 2000). To meet such diverse needs, providing multiple input and output options, such as letting the user choose between speech recognition and keyboard input, can be beneficial.

5.1.2 Communication impairment

Impairment in communication skills is a significant aspect of autism. Children with autism are often visual learners, so it is recommended to provide a visual prompt, such as an icon, along with any verbal or written information given (Quill, 1997; Shane et al., 2009). Icons should be simple and clear and used only when they add meaning without contributing to sensory overload. Provision of multiple input and output modes is also important in the context of the communication difficulties. For example, expecting a learner with communication difficulties to write lengthy sentences when language skills are not the

lesson focus only serves to discourage and distract from the social skills concepts being taught. Instead, point and click interfaces and other simple interaction modes may better allow students to express and explore their knowledge without communication barriers.

Following this idea, written information should be in the form of simple, concise sentences. Learners with autism can miss subtle cues and become confused or distressed by ambiguity, so instructions must be in clear, simple steps and scaffolding used to move learners from basic concepts to more complex ones as their skills improve (Brown et al., 2001; Parsons et al., 2000; Silver & Oakes, 2001). Self-paced lessons are ideal as they give learners control and ownership of the learning process, lowering anxiety and helping with content retention.

5.1.3 Generalisation to novel contexts

It is not unusual for learners with autism to improve at an intervention task, but fail to exhibit the same improvements in their everyday interactions (Bosseler & Massaro, 2003; Silver & Oakes, 2001). One tactic to facilitate generalisation is to embed tasks in real world situations, allowing the learner to understand its social value. Another is to expose the learner to sufficient variety within a task, in an effort to assist with generalising to novel contexts (Bosseler and Massaro 2003). In the case of a software-based intervention, this means exposing the learner to a range of media, for example when teaching recognition of emotions, instead of using only photographs, also include videos and drawings. With an animated virtual tutor, the ability to change the tutor's appearance and voice may also be beneficial as it is analogous to having a student role play situations with a variety of peers instead of just one. This avoids the learner associating the task with a single presenter and helps them identify common elements across multiple situations. Additionally, presenting predictable tasks does not mean identical tasks, as variety encourages generalisation. Instead, tasks should follow a predictable pattern, warn the learner prior to major deviations, but be somewhat different with each presentation.

5.1.4 Supporting learning

When teaching individuals with autism, Silver and Oakes (2001) emphasise the importance of providing opportunities to repeat tasks in order to reinforce the concepts within them, and stress the need to provide timely and accurate feedback so learners understand where they went wrong, why and what to do next time. Children with autism have difficulty learning from their own mistakes, so such feedback is vital. Tartaro and Cassell (2006) and Silver and Oakes (2001) both state that providing tasks that are inherently reinforcing and rewarding leads to the richest outcomes. Tartaro and Cassell (2006) add that social skills interventions should provide a safe environment for children to practice their skills in, as neurotypical peers can be critical of the learner, and that the use of roles can help children understand the dynamics and social conventions involved in social situations. Children with autism, just like their neurotypical peers, are individuals and thus interventions should be customisable to their personal needs and skills. In the case of virtual tutors, much can be adapted to the child including, but not limited to, the appearance and voice of the virtual tutor and the content and format of the lessons provided.

5.2 Identifying a social skills curriculum

Selecting a suitable curriculum for implementation in social tutoring software is important, thus we propose a set of guidelines for this process. First, the curriculum should cover an appropriate skill set at an appropriate level of difficulty for the software's target audience.

Lower functioning and younger students are likely to require a simpler curriculum, while older and higher functioning students may require a curriculum that covers more subtle aspects of social competency. Ideally, a curriculum will be accompanied by specifically designed assessment tools. The next major consideration is that the chosen curriculum should be formally evaluated with positive experimental results. Evaluations should include data on generalisation and maintenance of taught concepts, as these are areas where many existing interventions fall short (Bosseler & Massaro, 2003; Silver & Oakes, 2001). Ideally, a curriculum developed specifically for children with autism, or at a minimum one with experimental support as to its appropriateness for this learner group, should be used. This can be challenging, as many of the social skills curricula available have been developed for neurotypical students. To remain as true to the original curriculum as possible, it is important that activities can be translated into a software context with minimal changes. Too many deviations from the original curriculum and they are no longer comparable. Finally, cultural appropriateness should be considered, thus a locally developed curriculum or one being used with success in local schools is preferred.

5.3 Training methods

When selecting training methods for implementation in social tutoring software, we propose that the approaches must meet several criteria. First, it must be possible to robustly implement the chosen training method in a software context, for example having a speech-recognition based conversation on an open-ended topic is not a viable option given the current state of the art (Schuller et al., 2009). However, having the learner speak answers to questions using key words, for example yes or no, is achievable. Another criterion to be met is that there should be existing evidence of the value of the chosen method for use with children with autism. Methods must be suited to teaching the concept or procedure at hand, for example video modelling a very abstract concept is unlikely to be effective, however, using diagrams or concept maps may be. Where possible, a range of approaches should be offered to the learner, particularly if they are having difficulty. It is often seen that where one approach fails, another will succeed.

Training methods previously discussed that have been identified as fitting the criteria for social tutoring software include modelling, including video modelling shown as media clips on-screen and tutor modelling, where the animated tutor acts out behaviours, for example facial expressions (Reichow & Volkmar, 2010). Simulated role-plays and scenarios are also possibilities, although these must be structured in such a way as to be robust to unexpected user responses and behaviours. For example, a completely open-ended scenario may not be viable, but one where the user can select from a large range of presented options is both flexible and easily implemented in software. Direct teaching is a commonly used technique in educational software; while sometimes criticised as not challenging learners to construct their own knowledge, with communication-challenged learners it is a valuable tool. To effectively use direct teaching, emphasis must be put on providing clear steps and explanations for the learner and presenting content in a scaffolded manner (Kerr, 2002). Concept maps are another valuable technique, shown to be effective in paper-based form for teaching social skills to children with autism (Laushey et al., 2009). When structured appropriately concept maps can be automatically analysed in software, are highly visual, suiting the common learning style of those with autism, and help learners to identify connections between concepts, and cause-and-effect relationships. Wherever possible, a

range of these methods that meet the selection criteria should be used to teach each concept, as the variety will assist in maintaining learner interest and motivation as well as increasing the chances of exposing the learner to a task that they find best explains the new concept.

5.4 Assessment methods

In order to present students with learning tasks suited to their current needs, it is essential to continually assess their state of knowledge in a robust and accurate manner. It is often seen that students learn how to complete a task or pass a topic without gaining any deep understanding of the topic material covered (Conati, 2002). It is thus essential to assess student knowledge continually so that needed adjustments to learning tasks can be made.

It is proposed that selection criteria for assessment methods reflect the criteria proposed for training methods, in that the approach chosen must be robustly implementable in a software context, established as both valid and effective for use with children with autism, and provide an accurate picture of mastery of the targeted concept or skill. One example is the use of established social skills scales and checklists, such as MESSY or SSRS (Wilkins, 2010; Williams White et al., 2007). Some list items may be assessable as part of the software, for example sequencing and reasoning tasks, while others, such as those requiring observation, are not suitable for automatic assessment, however, the software could provide an option for these items to be manually entered. Being open-ended, management of these entries must be conducted carefully. Information from scales, checklists and observations will assist in continually updating the student model held by the software and thus used to inform decisions regarding what content to present and how to present it.

Two approaches that can be used for both training and assessment are scenario-based approaches and concept mapping (Crisp & Ward, 2008; Park & Calvo, 2008). In a software environment there is a concern that learners will be able to respond to learning activities correctly without truly understanding the ideas being taught. Scenarios and concept mapping attempt to address this. With concept maps, learners must demonstrate their understanding of relationships between concepts in a visual manner. Participants are typically provided with labelled nodes and must arrange and connect these appropriately. To accurately complete a concept map without fully understanding the concepts involved is unlikely and so concept mapping provides us with better look at a learner's understanding than many traditional assessment approaches (Park & Calvo, 2008). With scenario-based approaches, learners are presented with a situation and are required to select a response. This list can include distractor items with varying subtlety and similarity to the desired answer. Additionally, learners can be requested to select or provide a justification for their choice, and be presented with self-reflection questions (Crisp & Ward, 2008). Carefully structuring the assessment task ensures it is a flexible and rich experience, while providing suitable information for computer automation. As with the training approaches implemented, the assessment tasks chosen depend heavily on the content being taught, and similarly it is often advisable to assess content using multiple techniques. Doing so results in a more accurate picture of student understanding.

6. Conclusion

Tools to assist children with autism to develop their social competence are in demand, according to a recent survey (Putnam & Chong, 2008). ECAs as virtual tutors appear to be

a promising avenue for addressing this need, as children with autism report an affinity for technology, feel more comfortable interacting with it than with peers, and existing work in similar areas is thus far producing encouraging results (Bosseler & Massaro, 2003; Tartaro & Cassell, 2006). ECAs, such as Head X (Luerssen et al., 2011), are highly customisable and, when coupled with an appropriately computerised social skills curriculum, have much potential to provide a flexible, stress-free and self-paced learning tool for individuals with high functioning autism and Asperger Syndrome. To achieve this, the social skills curriculum, training methods and assessment tools must be carefully chosen. Selection criteria for these include that they must be implementable in a computerised context, must have established effectiveness and applicability to learners with autism and must be suited to the social skills concepts targeted. Additionally, the learning style of the individual must be supported, visual learning is dominant for the target user group, and other particular challenges, such as sensory issues, must be addressed effectively. By addressing these considerations it is envisioned that a valuable ECA-based learning tool, that is one that is adaptable, motivating and suited to independent use, can be successfully developed.

7. References

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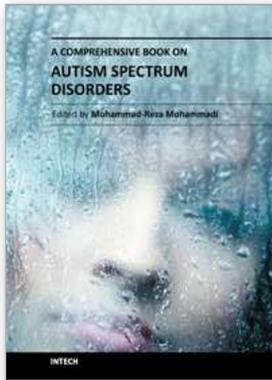
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The aim of the book is to serve for clinical, practical, basic and scholarly practices. In twentyfive chapters it covers the most important topics related to Autism Spectrum Disorders in the efficient way and aims to be useful for health professionals in training or clinicians seeking an update. Different people with autism can have very different symptoms. Autism is considered to be a "spectrum" disorder, a group of disorders with similar features. Some people may experience merely mild disturbances, while the others have very serious symptoms. This book is aimed to be used as a textbook for child and adolescent psychiatry fellowship training and will serve as a reference for practicing psychologists, child and adolescent psychiatrists, general psychiatrists, pediatricians, child neurologists, nurses, social workers and family physicians. A free access to the full-text electronic version of the book via InTech reading platform at <http://www.intechweb.org> is a great bonus.

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