

Virtual Reality Based Behavioural Learning For Autistic Children

Chandra Reka Ramachandiran^{1,2}, Nazean Jomhari², Shamala Thiyagaraja², Malissa Maria³

¹School of Liberal Arts and Sciences, Taylor's University Lakeside Campus, Malaysia

²Department of Software Engineering, Faculty of Computer Science & Information Technology, University of Malaya, Kuala Lumpur, Malaysia

³Sunway University, Bandar Sunway, Petaling Jaya, Selangor, Malaysia

chandrareka@hotmail.com

nazean@gmail.com

shamala.t@maybank.com.my

malissam@sunway.edu.my

Abstract: Autism is a disorder in the growth and development of a brain or central nervous system that covers a large spectrum of impairment, symptoms and skills. The children who are suffering from autism face difficulties in communicating and adapting well in the community as they have trouble in understanding what others think and feel. Therefore, there is a need to design effective e-learning method to ease the communication process and to deliver required knowledge to autistic children. Past researchers have highlighted that a virtual reality based learning environment, a computer simulated environment, can facilitate the learning process among autistic children. It is also recognized that the virtual agent plays an important role in virtual worlds as it eases the communication process between the virtual environment (VE) and children with autism. This research aimed to design an effective learning environment for autistic children by developing a virtual environment prototype using face-to-face interviews and picture exchange communication system (PECS) methodology for data collection which was analysed using quantitative tests. The findings suggest that the toilet virtual environment topped the list for being the most popular learning environment among autistic children for behavioural training. The designed prototype identifies autistic children's and their parents' needs and also addresses limitations in an existing virtual environment.

Keywords: autism, picture exchange communication system (PECS); virtual environment (VE); virtual agent

1. Introduction

Virtual reality enables e-learners to visualise the learning process, manipulate findings with relative complex sets of data and interact with current technologies (Kadir & Xu, 2011). The visualization process refers to visual representation in computers, auditory components or any other forms of sensory outputs displayed in a virtual world. According to Abdul-Kader (2008), the virtual reality can be classified into three categories; desktop virtual reality, fish tank virtual reality and immersive virtual reality. Additionally, he concluded that applications of virtual reality have the potential of developing into a wider spectrum, which can diverge from entertainment purposes to educational purposes. On the other hand, the most recent application of virtual reality is the interface to e-learning applications, which is also known as virtual reality based e-learning tool. The potential of virtual reality tool is demonstrated by its ability to facilitate learning processes while avoiding many problems characterizing traditional or conventional teaching learning methods.

A multitude of e-learning educational systems that were developed recently incorporates virtual environments. Most of the medical and scientific subjects are the leading e-learning applications that use virtual reality technology (Dimitropoulos et al., 2007; Huang et al., 2010; Albeanu, 2008). With this in mind, many virtual classrooms are set up to facilitate virtual learning in educational institutions and training centres. It is also noted that over the years, advancement in the virtual reality technology has opened up numerous application possibilities such as providing guidance for disabled children (Albeanu, 2008; Reid, 2011; Kandalaft et al., 2013). Therefore, in a hope of broadening the studies that have already been done, this research focused on enhancing and facilitating the learning process of the specified target group of autistic children.

Several countries abroad have been implementing caretaking service centres and nurseries to assimilate an education for these children with special needs. In Malaysia, the government has taken the initiative to set up centres such as Fakh Intellect Academy, Cads Enhancement Centre, Kidzgrow and Chatterkidz Therapy to assist autistic children's parents and caretakers to educate the autistic children effectively. Most of the

children in these facilities suffer from poor social interaction, lack of communication skills, and portray unusual and distinguishing behaviours similar to the scenario elaborated by Zander (2004). On account of such issues, some specifically designed teaching methods have been made available to allow autistic children to learn better, for example; applied behavioural analysis (ABA), treatment and education of autism and related communication handicapped children (TEACCH), floortime, social story, and picture exchange communication system (PECS) etc. (Selva & Marin, 2001).

Despite of all the possible advantages of implementing virtual reality based tools the teaching methods stated above still possess various disadvantages. These disadvantages could include any of the following: requiring special guidance, skills domination, imagination problems, equipment storage and deterioration of storage medium (Selva & Marin, 2001). However, most researchers have considered virtual reality based learning tool to be an effective tool for autistic children to facilitate the teaching learning process (Albeanu, 2008; Reid, 2011; Kandalaf et al., 2013). To add on, VE provides great potential for people with autism because users can play a role in an environment designed to imitate definite social situations. The increasing sophistication of VEs means that skills and tasks can be practiced in realistic settings. This has been identified as an approach that gives encouraging support to enhance the children's social skills (Strickland et al., 1996).

Autism is a spectrum of closely-related disorders with a shared core of symptoms. Every individual on the autism spectrum has problems to some degree with social skills, empathy, communication, and flexible behaviour (Mesibov et al., 2000; Happé & Frith, 1996). Due to this, to educate autistic children on social skills, a flexible and interactive teaching method or technique should be established. This learning style must be an enjoyable learning process that allows them to gain more and experience the real scenario via the implemented system. However, the majority of the prevalent methods of teaching aids available to autistic children have certain drawbacks in terms of enhancing social skills. Alternatively, there are many applications available online to serve this purpose, but it might be time-consuming due to the time required to download such applications. Additionally, it might also require more digital storage space depending on the size of an application in certain mobile devices. In Malaysia, mobile technology is an emerging technology and is gaining wide popularity. However, this technology is not owned by the majority and therefore there is some limitation to the access of smart phone applications that cater to needs of autistic children. It has been observed that many parents do not own smart phone technology to provide behavioural training to their autistic children via virtual reality based behavioural training and learning resources due to the high cost.

Several online applications also demand the user to spend more time in constructing a social story, whereby, the user is required to create a virtual environment for a specific behavioural training. Apart from that, it is not an easy task to obtain a suitable graphic to be used as a teaching and learning material for autistic children. However, it is important to use effective graphics in the virtual environment as it is a more appealing tool for teaching these children. Hence, pictures used should be realistic and cater to educational needs (Simon et al., 1986). The research aimed to create a virtual environment for autistic children that includes a virtual agent which can role play to educate autistic children on 'how to behave' at specific places or scenarios. Aligned with this, the derived objectives of this research are as follows:

- To identify the virtual environment (VE) needed for the behavioural learning process of autistic children;
- To ascertain the virtual environment (VE) requirements to educate autistic children; and
- To evaluate the prototype for virtual reality based learning application which includes virtual agents.

2. Literature Review

Autism is comprised of severe enveloping impairments in several important areas of development in a person. These impairments could be any of the following examples; social interactions, communication, behavioural, and imaginative (Happé & Frith, 1996; Wing & Gould, 1979; Wing, 1998). The majority of autistic children encounter learning difficulties, even though some might have been equipped with an average intelligence (Sallows & Graupner, 2005; Pinker, 1999). The disability of these children can also fall under the categories of epilepsy, visual and auditory problems. Autism is related to the behaviour of a person as an effect of unknown biological dysfunctions of the brain that has consequence on the development or reaction of the brain while handling information. This dysfunction can range from issues that lie between any of the received information, processed information or even interpreted information (Mesibov et al., 2000).

Autistic children mostly suffer from poor social interaction, communication, behaviour, and large variations in learning abilities (Zander, 2004). In the article entitled “Introduktion om autism”, Zander (2004) asserted that social interaction is a main issue encountered by autistic children, whereby the children have difficulties in conducting eye contact, body language, facial expression, and modulation (Church et al., 2000). Many autistic children are unable to show social or emotional feedback and do not share their feelings with others (Ozonoff, & Cathcart, 1998). It is also noted that autistic children do not share similar interests as other children of the same age. Even if they do, they are unable to express themselves well and develop and maintain friendships. Autistic children are naturally delayed in language development (American Psychiatric Association, 2000). Hence, most of these autistic children develop poor speaking skills as it is a difficult task to promote social and communication skills in children with autism (Zander, 2004). Besides this, they also exhibit unusual, distinguishing behaviour which includes limited interest and concerned on a specific object, hard adherence, and flexible observance to non-functional regularity. Zander (2004) also highlighted examples of such distinguishing behaviours such as spinning the wheel of a toy, lining up toys repetitively, yet seldom engage themselves spontaneously and picking up different games and role plays.

Besides this, Zander (2004) also concluded that the level of seriousness in autistic children varies from one individual to another in terms of intelligence and learning ability. This might be due to several causes such as depression, the nature of the autism disorder, epilepsy, genetic symptoms, etc. Hence, the need to develop an attractive and an effective method to teach these children arises. There are several effective teaching methods identified to be used while educating these autistic children. Table 1 below shows several popular teaching methods for these special children.

Teaching Method	Description
Applied Behavioural (ABA)	Learning method by using an alphabetical model in order for them to be more focussed, responsive and imitate (Birnbauer & Leach, 1993; Sallows & Graupner, 2005).
Treatment and Education of Autism and Related Communication Handicapped Children (TEACCH)	A type of teaching method that is more structured and can be applied at home and classroom as well (Mesibov, Shea, & Schopler, 2005). This method focusses on the changing environment which suits children according to their needs. However, this technique requires the parents’ active participation (Ozonoff & Cathcart, 1998).
Floortime	A method whereby the trainer enters the children’s world and looks at things from their perspective to provide help to expand their thoughts and ideas (Greenspan & Wieder, 1997). The highlight of this method is its ability to incorporate two-way communication skills, expression, ideas and feelings within its educational purposes (Selpa & Marin, 2001).
PECS (Picture Exchange Communication System)	Parents and caretakers are required to participate in an intensive training on how to use binders and picture cards as it comprises of 6 phases which can be considered as rather time consuming (Bondy & Frost, 1994). Furthermore, this meta-analysis analyses the extant empirical literature for PECS relative to the targeted (functional communication) and the non-targeted concomitant outcomes (behaviour, social skills, and speech) for learners with autism, learners with autism and intellectual disabilities, and those with autism and multiple disabilities (Ganz et al., 2012).
Social Story	Social Story was developed by Carol Gray which began in 1993; it was used to teach disabled children by providing accurate information in challenging situations (Reynhout et al., 2008). Social Story also provides guidance by describing the patterns on performing an action in sequence.

Table 1: Teaching Methods for Autism Students

A virtual reality based learning tool that includes a virtual environment (VE) and virtual agents is an effective method to support the social communication skills of children with autism. In such conditions, where social skills can be practiced repeatedly, the result possess a less threatening, less social challenging, more

controllable and comfortable process when compared to a face-to-face communication scenario (Rajendran & Mitchell, 2006). Besides this, it also allows the user to truly see on the screen rather than how the environment is actually encountered in real life. For example, the user would experience this via a standard personal computer and headsets (Parsons et al., 2004). It is also noted that the popularity of virtual agent technology is due to its support to component based software engineering, flexible operations, easy software maintainability, adaptability to the real world and an extensibility of the software itself. Virtual agents have become increasingly prevalent in human computer interaction (HCI). Among the examples are embodied conversational agents and avatars. Embodied agents can be defined as 'Interfaces based on the anthropomorphic metaphors, which look human-like and mimic a face-to-face interaction style.' Examples of various embodied agents used in HCI research are embodied conversational agents (ECA's), relational agents (RA's), pedagogical agents (PA's) and chat-bot agents (Ramachandiran & Jomhari, 2014). The ECA's are synthetic characters that can maintain a conversation with a user. Hence, many virtual-reality based learning tools use virtual agents to deliver knowledge and skills to autistic children.

Virtual environments also include the representation of people or virtual agents and objects which have been used in various fields for cognitive treatment (Sarah et al., 2004). For example VE has been used in overcoming dizziness among autistic children and pteromerhanophobia of some patients (Rothbaum & Hodges, 1999; Chorpita, 2014). VE has also been used in helping disabled people develop everyday skills (Brown et al., 1999). According to Parsons et al. (2004), VE is one of the tools which can be used in teaching a social story for autistic children. Past research also highlights an individual case study conducted to produce a report based on an observation and comments from two autistic children using two different virtual environments such as virtual cafe and virtual bus environment (Parsons et al., 2006).

3. Research Methods

This research used a mixed methodology comprising both qualitative and quantitative analysis. The qualitative method focuses on an interview and an observation survey. The interview was conducted as part of the preliminary study for this research. Besides conducting interviews, the student observation was also carried out during this face to face interaction session. The quantitative method was then used to analyse findings of this research that uses the PECS teaching method for autistic children (Bondy & Frost, 1994). It is clear that PECS is a communication method that does not require speech and has been widely used in various researches pertaining to autistic children. It is based on an exchange of a picture of a real object by finding and reaching for someone's assistance to deliver the message effectively. With that exchange, the children themselves start the act of communication. Thus, the main objectives of using PECS set by the researchers are that the child initiates the communication, finds and approaches a communicative partner and uses only one picture in order to avoid a confusion about what he or she wants (Bondy & Frost, 2002). Not only disabled children, but normal children can also use PECS to communicate and deliver messages effectively. The research is divided into four phases as depicted in Figure 1.

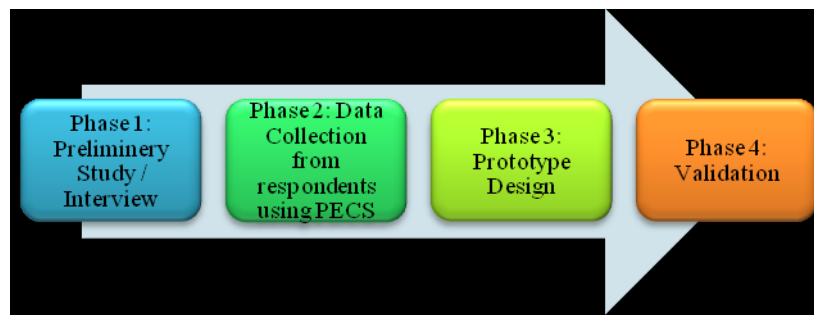


Figure 1: Four Phases

The data collection process is one of the most important tasks in any research project. An incorrect or an inaccurate data collection may affect research findings. The data collection can be divided into quantitative method and qualitative method. Interviews and questionnaires are categorized under the quantitative method, whereas, the in-depth interview, observation methods and document review are categorized under the qualitative method. In this research, face-to-face interviews with parents were conducted to gather information on the essential needs and VE design criteria for their children. Phase 1 is the preliminary research

phase, in which the respondents were interviewed. The respondents identified for this research are the parents of autistic children. A total of 41 parents participated in this phase of research. The objective of this phase was to identify the virtual environment required for learning. This was conducted in an autistic learning centre, Fakh Intellect Academy located in Malaysia and in the presence of 41 autistic children. The selection criteria of the environment were divided into two classifications, which was the indoor and outdoor. In the indoor criteria, the researcher selected the bedroom, toilet, kitchen, living room, and dining room. Alternatively, for the outdoor criteria, the environments selected included classroom, shopping mall, hospital, bus, and café.

Once the virtual environment design criterion is defined, the PECS methodology was used to select the best fit specimens or objects related to the chosen environment. One of the main reasons why PECS was used is because the picture exchange communication system (PECS) is a widely accepted picture or icon aided augmentative communication system designed for learners with autism and other developmental disorders (Bondy & Frost, 1994; Ganz et al., 2012). Figure 2 depicts the specimens used in the Phase 2 of this research. All objects / specimens are related to the toilet virtual environment, as it is the outcome of the preliminary study in Phase 1.

Toilet design	 Specimen 1	 Specimen 2	 Specimen 3	 Specimen 4
Flushing System	 Specimen 5	 Specimen 6	 Specimen 7	 Specimen 8
Wash basin	 Specimen 9	 Specimen 10	 Specimen 11	 Specimen 12
Tap	 Specimen 13	 Specimen 14	 Specimen 15	
Virtual Agents	 Specimen 16	 Specimen 17	 Specimen 18	 Specimen 19
	 Specimen 20	 Specimen 21		

Figure 2: Research Specimen

On the other hand, Phase 3 focuses on the prototype design using all the selected specimens from Phase 2 by the 41 respondents. Next, Phase 4 validates the prototype finalised during the Phase 3. During this phase, the prototype for the toilet virtual environment is viewed and validated by the respondents. An interview was conducted to gain information to enhance the prototype design and to validate the design. The role of virtual agents was also identified in this phase of research.

3.1 Respondents

Respondents for this research are both parents and autistic children. Face-to-face interviews were conducted to gather required information. During the preliminary study, an interview was conducted with 41 respondents. Then, an online questionnaire was distributed among the same group of people aged from 20 – 50 years. To conclude, a total of 41 parents have participated in this research from which, 31 of the sample respondents were female (76%) and the other 10 were male (24%). The respondents are from the various ethnic groups, 15 were Malay, 7 Chinese and 19 Indian. For autistic children respondents, 29 respondents (71 %) are male and 12 respondents (29%) are female.

4. Analyses and Results

In the preliminary study, the environments were categorised into 2 categories of indoor and outdoor. Several types of environments were listed in the indoor categorization such as the bedroom, toilet, kitchen, living

room, and dining room. From the listed environments, the most preferred environment ‘toilet’ scored a significant 66%, making it the most requested training options. As for outdoor environments, the listed types of environments are the classroom, shopping mall, hospital, bus, and café. From the entire scenario, the classroom environment was selected by 46% of the parents as outdoor environment training requirement. Alternatively, the indoor environment toilet was selected by most respondents. Table 2 summarizes the findings in relation to respondent’s virtual environment preference.

Environment Types	Percentage (%)	Total
Indoor		
Bedroom	46	
Toilet	66	
Kitchen	51	54.28 %
Living room	49	
Dining Room	60	
Outdoor		
Classroom	39	45.82 %
Shopping Mall	51	
Hospital	50	
Bus	40	
Café	50	

Table 2: Respondents Virtual Environment Preference.

From the findings of Phase 1 of the research, the prototype design, implementation, and testing were carried out. In this case, the toilet VE (Indoor) was designed. A few types of the toilet, tap, flush, and washbasin were selected and presented to parents. Among the specimens, the highly rated specimens are depicted in Table 3. Table 3 summarizes the outcome from Phase 1 showing the preference and the percentage of votes for the toilet VE.

Toilet object / specimen criteria	Highest vote using peccs (%)	Other votes (%)
Toilet Design	Specimen 1 (85%)	Others (15%)
Flushing System	Specimen 5 (80%)	Others (20%)
Wash basin	Specimen 9 (100%)	Others (0%)
Tap	Specimen 13 (60%)	Others (40%)
Virtual Agents	Specimen 16 (40%)	Others (60%)

Table 3: Toilet VE Specimen Preference

A total of 41 parents and 41 autistic children participated in the testing phase. The role of the parents in this phase that uses the PECS methodology was to facilitate children to communicate and choose the specimens. Based on an outcome, the parents who participated preferred the sitting type toilet design (Specimen 1)

compared to the other specimens in the same category. From this finding, we can conclude that 35 parents (85%) preferred sitting toilet (Specimen 1) and the remaining 6 respondents (15%) voted for other specimens from the same category.

However, the height of the sitting toilet remains a major concern for parents as a minority of autistic children suffer from acrophobia, which is the fear of height. The finding supports the evidence of previous research examining the types and frequencies of fears in children with autism where the findings show odd and intense fears in approximately 40% of children (Chorpita, 2014). To elaborate further, squat toilets are not popular among parents due to hygiene concerns. It is also noted that some children have the habit of fiddling with objects around the toilet and therefore several safety precautions must be taken.

Based on the interview, most parents preferred tap (Specimen 13) due to ease of use. On the other hand, flushing system (Specimen 5) was rated the most popular as it is easy to operate and children with autistic disorder can adapt to this product design faster and for the wash basin category specimen 9 topped the list.

Virtual Agents (Specimen 16) gained wide popularity as 70% of the autistic children are Male and the respondents believed that it is more practical and makes the virtual world seem real to design a prototype with a male agent. A total of 16 respondents opted for this virtual agent and is very popular among autistic children.

5. Discussion and Conclusion

There is an increasing recognition that successful learning requires not just quality instructional content, but also an appropriate context that includes facilitation and an understanding of the e-learner. In this case, autistic children need an effective learning tool not only to develop their knowledge, but also their behaviours. It is noted that due to the autism disorder, these children develop unusual fears which limit their ability to carry out their daily chores (Zander, 2004; Sheinkopf et al., 1998). Though, there is a wide domain of virtual reality based learning tools that are available today, but only a few selections of tools are useful for autistic children. Therefore, virtual reality based environment for educating autistic children must be given serious consideration as these tools can assist in the learning process and minimise their level of fear. This is similar to the findings from the research conducted by Selpa and Marin (2001).

In this research, a prototype of the toilet virtual environment with a virtual agent was designed for behavioural learning among autistic children. The fact still remains that any virtual environment application should be created based on a prototype that has been developed and tested repeatedly. The research should include a wider group of different parents of both normal and disabled children. Figure 3 below depicts the proposed toilet VE for autistic children. This proposed virtual environment was created based on research findings and can be implemented to guide autistic children in behavioural training.

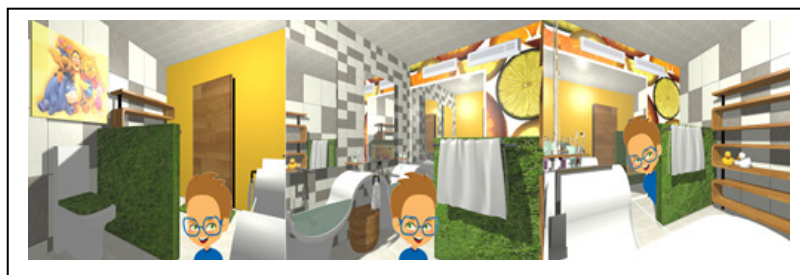


Figure 3: Virtual Toilet (view from three different perspectives)

Apart from the selected objects or specimens used in the proposed virtual environment, there are other concerns highlighted by parents. Among the additional specimens requested by them are mirrors, bathroom mat, tissue, towel, air freshener, and plants. Other equipment requested for include ventilation, soap holder, towel holder, tissue holder and dust bin. Some respondents requested for more unique toilet VE items such as a small hand towel to cover a Muslim child's head, shelves and decorative items for a cosy environment. Additionally, this design incorporates the various specimens from the PECS data collection and also cultural aspects. While Malaysia is a multiracial country having many cultural barriers, this design managed to

harmonise cultural differences and the virtual environment is well accepted by respondents from various ethnicities in Malaysia such as Malay, Indian and Chinese. Figure 3 depicts the proposed prototype design.

While designing the prototype, the researchers took into consideration that different autistic children have different capabilities. Some disabled children might be more aggressive or physically weaker than normal children. Therefore, all the specimens used in this prototype design are easy to use and less complicated.

Another interesting finding from this study is that the age of parents does play an important role in the teaching process of autistic children as younger parents are more afraid in handling children and seem very depressed with the condition of their children where older parents are more confident and understand the nature of autism. Sufficient training must be provided to parents to educate them on the nature of the disease and as it can affect the mental growth of children since parents are their role models and facilitators.

Although this study has provided valuable insights, it has some limitations that can be addressed through adopting a larger sample. With advancement in technology, future research on virtual reality based learning can be used to address the unusual fears among autistic children such as mechanical things, heights, weather, places, and visual effects as discussed by Chorpita (2014).

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