CYPRUS UNIVERSITY OF TECHNOLOGY

FACULTY OF FINE AND APPLIED ARTS

Master Thesis

Towards Effective Immersive Visualizations for the Training and Enhancement of Social Skills for Children with Autism

Skevi Matsentidou

Limassol 2013

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FACULTY OF FINE AND APPLIED ARTS

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TOWARDS EFFECTIVE IMMERSIVE VISUALIZATIONS FOR THE TRAINING AND ENHANCEMENT OF SOCIAL SKILLS FOR CHILDREN WITH AUTISM

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APPROVAL FORM

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Presented by

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ABSTRACT

Autism is a complex developmental disorder characterized by severe impairment in social, communicative, cognitive and behavioural functioning. Several studies investigated the use of technology and Virtual Reality for social skills training for people with autism with promising and encouraging results (D. Strickland, 1997; Parsons S. & Cobb S., 2011). In addition, it has been demonstrated that Virtual Reality technologies can be used effectively by some people with autism, and that it has helped or could help them in the real world; (S. Parsons, A. Leonard, P. Mitchell, 2006; S. Parsons, P. Mitchell, 2002).

The goal of this research is to design and develop an immersive visualization application in a VR CAVE environment for educating children with autism. The main goal of the project is to help children with autism learn and enhance their social skills and behaviours. Specifically, we will investigate whether a VR CAVE environment can be used in an effective way by children with mild autism, and whether children can benefit from that and apply the knowledge in their real life. The training will focus in real life situations which are difficult or impossible to explain to children with the known methods of treatment. Like an unsafe situation or a situation where the child must experience it, in order to learn how to act (e.g. crossing the road).

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INTRODUCTION

Autism is a complex developmental disorder characterized by severe impairment in social, communicative, cognitive and behavioural functioning. Several studies investigated the use of technology and Virtual Reality for social skills training for people with autism with promising and encouraging results (D. Strickland, 1997; Parsons S. & Cobb S., 2011). In addition, it has been demonstrated that Virtual Reality technologies can be used effectively by some people with autism, and that it had helped or could help them in the real world; (S. Parsons, A. Leonard, P. Mitchell, 2006; S. Parsons, P. Mitchell, 2002). The goal of this research is to design and develop an immersive visualization application in a VR CAVE environment for educating children with autism. The main goal of the project is to help children with autism enhance and improve their social skills and behaviours. Specifically, we will investigate whether a VR CAVE environment can be used in an effective way by children with mild autism, and whether children can benefit from that and apply the knowledge in their real life. The training will focus in situations of real life which are difficult or impossible to explain to children with the known methods of treatment. Like an unsafe situation or a situation where the child must have an experience of it in order to learn how to act (e.g. crossing the road).

We address the following research questions:

- Can virtual reality technologies, and in particular the aforementioned application, be effectively involved in enhancing the social skills and behaviours of children with autism?

- Can the immersive visualization application be considered as a new and innovative method of treatment?

Autism is a complex developmental disorder characterized by severe impairment in social, communicative, cognitive and behavioural functioning. It belongs to a group of disorders known as Autism Spectrum Disorder (ASD) and a broader category of pervasive developmental disorders (D. Strickland, 1997).

Autism Spectrum Disorder (ASD) is characterized by impairments in social interaction, social communication and imagination, stereotyped and repetitive behaviours and a resistance to change in routine. Intellectual disability is present in a large proportion of individuals (B. Robins, K. Dautenhahn, R. te Boekhorst, 2005; G. Dawson, 2010; K. Dautenhahn, 2000).

Some basic characteristics of people with autism are reduced emotional attachment, absence or abnormal speech, ritualistic behaviours, aggression and self-harm. Typical is also the lack of eye contact (Matson J.L., Matson M.L., Rivet T.T., 2007; C. Lord, 2000), attention deficit, motor incoordination, symptoms of anxiety and depression (E. L. Hill and U. Frith, 2003). In addition some other characteristics are the reduced repertoire of activities and interests, and a tendency of fixation to stable environments (K. Dautenhahn, 2000).

Recent research investigated the use of virtual environments for social skills training, as an augmentation to existing methods and approaches. People with ASDs had the ability to use Virtual Environments (VEs) successfully, and learn simple social skills using the technology. VR technologies provide safe, realistic-looking 3-D scenarios that can be built to depict everyday social scenarios. The possibility of exploring these scenarios in real-time makes them an attractive tool for teaching social skills to people with ASDs (S. Parsons, A. Leonard, P. Mitchell, 2006).

Moreover, people with autism have difficulty in making sense of the world, in particular the social world (K. Dautenhahn, 2000). Social skills training based on the treatment of human social behaviours (eye-contact, joint-attention, approach, avoidance, following, imitation games etc.) and interactions. The goal is for people with ASDs to learn to initiate, to sustain conversations and to understand the social rules that govern everyday behaviour (S. Parsons, A. Leonard, P. Mitchell, 2006). They can learn memories rules about what kind of behaviours is socially appropriate during interaction with other people (K. Dautenhahn, 2000).

Based on information provided by the Cyprus Autistic Association (2009) about various treating methods they currently employ, an interesting treatment method of enhancing social skills is the so called ‘social stories’. Social stories is an educational strategy developed by Carol Gray (The Gray Center) which aims to teach people with autism how to carry out some social processes in their daily life through story telling. A social story is presented with the help of pictures in a specific order and shows the performance of an action. For example, a story explains the actions that must be performed in order for the person to get ready and leave the house, get ready for bed, or take care of himself as shown in Figure 1. Other stories include actions such as ‘taking a bath’, ‘brushing your teeth’, ‘visiting the barber’, ‘why and how we hug’.

Figure 1: Social Story – 'Taking care of myself'

A study (K S. Thiemann and H. Goldstein, 2001) that investigated the effects of social stories, written text and pictorial cuing with supplemental video feedback on the social communication of 5 students with autism and social deficits, showed increases in targeted social communication skills when the treatment was implemented. In addition, the results of the study support clinical recommendations for using social stories to guide the social communication development of children with autism (K S. Thiemann and H. Goldstein, 2001).

In this work, we present the design and development of an immersive visualization application for the treatment of social skills for children with autism which unifies the advantages of the 'social story' teaching method and state-of-the-art technologies and in particular a VR CAVE. The goal is to develop virtual social stories in an immersive VR

CAVE environment which will be used to educate children about some specific social skills or actions occurring in the real world.

The training will focus on real-life situations which are difficult or impossible to explain to children using the traditional way - pictorial cuing. For example, consider an unsafe situation or a situation where the child must experience it in order to learn how to act e.g. crossing the road or avoiding cars. The treatment will focus on situations where the child will be alone and helpless in an unknown place. For example, consider the scenario where the child wonders off in the city without his parents. It is very likely that he/she will not know how to react or what to do in order to find his chaperone. At the same tune, he/she should be prepared to calmly figure out what to do. The scenario of the "wondering off in the city" is extremely dangerous because of the cars, and other life hazards. The child should learn how to cross the road safely.

This thesis is organized as follows: Section 1 presents a brief overview of the state-of-the-art in the area of teaching with the use of virtual environments. Section 2 describes our methodology. In Section 3 the design and development of the application is presented and Section 4 describes evaluation procedures, experimental results, analysis and discussion.

1. Related Work

A plethora of work has been conducted in this area. Below we provide a brief overview of the state-of-the-art.

1.1 Technology in autism therapy

Researchers report that people with autism feel comfortable in predictable environments, and more specifically, enjoy interacting with computers and other technologies. An explanation is that the attention of people with autism tends to focus on isolated objects apart from the surrounding area. Computers manage to focus the individual attention of people with autism on the screen, so that external events can be ignored more easily. The use of computer-based learning in therapy and education of people with autism can be beneficial for the development of self-awareness and self-esteem. It can motivate them to speak, read or share achievements with others and facilitate communication. Additionally, it can effectively teach language and academic skills to them (B. Robins, K. Dautenhahn, R. te Boekhorst, 2005).

Studies have investigated diverse applications of technology – based interventions with children with autism. Technologies like tactile and auditory prompting devices, video-based instruction and feedback, computer-aided instructions, virtual reality and robotics have been effectively used in the treatment of children with autism. An interesting finding, resulting from many studies suggests that children with disabilities, including autism, prefer programs with higher interaction requirements, animation, sound, and voice features (T. Goldsmith, L. LeBlanc, 2004; B. Robins, K. Dautenhahn, R. te Boekhorst, 2005).

1.2 Virtual environments and autism

The benefits of using virtual environments as remedial learning environments for children with autism are many. The features of virtual environments which make them suitable as learning tools for children with autism are:

Controlled and safe learning environments: In virtual environments input stimuli can be controlled and the behaviour of the child can be monitored. Environments can be customized to account for individual differences. Children can be guided through learning experiences and explore new behavioural opportunities by themselves. Virtual learning environments can provide safe environments, a less dangerous and more forgiving environment for developing skills associated with activities of daily living. In addition, mistakes are less catastrophic compared with the real world (D. Strickland, 1997; K. Dautenhahn, 2000). Tina R. Goldsmith and Linda A. LeBlanc (2004) indicate that some of the most notable benefits of virtual reality are the incomparable control over the environment, and that it may offer a highly realistic but safe environment in which to teach skills that are associated with some level of danger when taught in the natural environment (T. Goldsmith, L. LeBlanc, 2004).

Generalization: An important issue and problem of all therapeutic approaches to autism is generalization. It is difficult to the child to generalize the learning experiences and apply the skills to non-classroom situations, even if the child shows improved performance in the classroom. Virtual environments have the benefit of changing dynamically, create alternative scenarios or variations, and increase the complexity of scenario very easy (K. Dautenhahn, 2000; S. Parsons, P. Mitchell, 2002). Few modifications across similar scenes may allow generalization. A child with autism who learns how to cross a virtual street, in one scene might generalize to another street scene if the differences are reduced until the similarities are recognizable. For example, two streets which are identical, except of the colour of one building. Differences could be increased slowly to teach cross recognition (D. Strickland, 1997).

A primarily visual/auditory world: Virtual environments highlight visual and auditory responses rather than other senses such as touch. Such responses effectively involved in teaching abstract concepts to people with autism. Individuals with autism indicate their thought patterns are primarily visual (D. Strickland, 1997).

Individualized Treatment: Individuals with autism vary widely in their abilities, strengths and weaknesses. Each individual may even demonstrate wide variation in skills and behaviour between different days. Taking this into account, an individualized approach of treatment and training based on a careful, personalized assessment is essential. Virtual environments deemed appropriate considering the ability to change dynamically and be customized based on each individual separately (D. Strickland, 1997; S. Parsons, P. Mitchell, 2002).

Preferred Computer Interactions: The complexity of social interaction can interfere when teaching individuals with social disorders. Human interaction can be so difficult and disruptive that learning is not possible. Children with autism are characterized by proactive behaviour, they prefer a predictable, structured and in this way 'safe' environment. They prefer to be in 'control' of the interaction and they respond well to structure, explicit, consistent expectations, and challenges provided by computers. Multiple studies have reported the advantages of computers in the treatment of autism. Virtual environments are stable, familiar, predictable, and allow children to learn basic social interactions in a consistent and accepting way (D. Strickland, 1997; K. Dautenhahn, 2000; S. Parsons, P. Mitchell, 2002).

Embodied Interaction: Virtual environment devices (e.g. VR helmets, hand controls), might be unacceptable for many autistic children, but for others might be appropriate. Approaches which support interactions involving the whole body seem highly promising; set ups where the child can move freely and is not constrained to sitting at a desk and is not required to wear special devices. The use of body and head trackers provides other advantages and possibilities. The movements and actions of an individual can be controlled in a virtual environment, allowing the system to adjust to a patient's actions. A large proportion of individuals with autism never learn to communicate, this calls for interactions in virtual scenes without verbal training from a teacher or other controllers (D. Strickland, 1997; K. Dautenhahn, 2000).

Immersion: The sense of immersion refers to the feeling of being part of, or engaged in a virtual scene. Feeling like you are really inside the virtual environment (Parsons S. & Cobb S., 2011). Parsons and Cobb (2011) report that in a research of Mineo (2009) the responses of 42 children with autism were compared to three different electronic media conditions. In the first condition the participant would watch a video of them engaged in an activity, in the second condition the participant would watch a video of someone else engaged in a VR activity and in the last condition in which the child engaged directly in activities within an immersive VR. The third condition was classified as the most immersive media condition, because children were more engaged with this technology – they spent more time looking at the screen. As the author points out, further investigation needs to be done, in order to check whether this aspect of VR can be translated into effective instruction and learning. Parsons and Cobb (2011) indicate another study of Wallace (2010), which explored the responses of adolescents with autism to an immersive 'Blue Room' (animations projected onto the walls, no headsets needed). Participants experienced scenes from a street, playground and a school and asked to rate their feeling of 'presence'. Results show positive experiences and that immersive VR has the advantage of allowing realistic and accessible scenes that could form the basis of important social role-play (S. Parsons, S. Cobb, 2011).

A study of Strickland, Marcus, Mesibov and Hogan (1996), showed that children with autism were able and willing to accept and interact within virtual reality worlds. It also demonstrated that children respond to the virtual world in a meaningful way, and tolerated wearing virtual reality equipment. Max and Burke in 1997 demonstrated that the virtual environment improved children's attention and performance across sessions (T. Goldsmith, L. LeBlanc, 2004). S. Parsons and P. Mitchell (2002), conclude that the virtual environment is an exciting tool that can extend the existing teaching practices and methods for social skills treatment for people with ASDs. Moreover, it provides a safe and supportive learning environment that succeeds in transferring knowledge between the virtual and real world (S. Parsons, P. Mitchell, 2002).

Therapists and teachers use virtual environments in order to teach social and other life skills to children with ASDs. For example virtual environments are appropriate to teach children how to recognize emotions, act calmly in a populated cafeteria and bus, safely cross the road and safely respond and manage in fire situations.

Strickland (1997) investigated the use of Virtual Worlds as a learning tool for children with autism. Two autistic children (a seven year old girl and a nine year old boy) took part in the study which consisted of over forty virtual exposures (each less than five minutes). The goal of the research was to help children with autism, cross a road safely. The first part of exposure was to train the child to recognize and track a moving car within a street scene. The second phase was to train the child to find an object and the colour of it in the environment, walk to it, and stop. Finally, with the learned skills the child should have the ability to cross a street alone. They used VR helmets to achieve immersion in the 3D environment, and the results proved that children are able to use them. In addition, the results have demonstrated that children immersed themselves in the virtual scene, were able to track the moving cars and verbally labelled objects and their colours. Also children tracked moving objects with their eyes, head and body turning and located objects (signs) and walked towards them. Because of the small number of participants the results cannot be generalized. The fact that the children accepted to use of VR devices and interacted with the environment with an effective way does not prove that every child with autism could do the same (D. Strickland, 1997).

S. Parsons, A. Leonard, P. Mitchell (2006), investigated the use of virtual environments for social skills training with two adolescent boys (14 and 17 years old) with ASDs. There are two types of VEs - a bus and a café – both of which were presented to participants on a laptop. For the navigation participants used a USB joystick and selected objects with a mouse. Feedback and instructions were provided through textual, picture and audible prompts from the program. In both VE scenarios, the user’s aim was to find an appropriate place to sit in an empty or busy café/bus and to ask appropriate questions when needed (e.g. if he can sit next to a stranger). Participants took part in a number of sessions and one session after 3 months, to check whether any new knowledge from the VE had been maintained over the summer school break. Results showed that they had remembered social knowledge gained during their VE sessions, they have a good understanding of the purpose of the VEs and were able to offer examples of how it had helped them, and could help them in the future. Also, participants seemed to enjoy the VE sessions and showed that they can learn about social ‘errors’ in a safe way, without any stress (S. Parsons, A. Leonard, P. Mitchell, 2006).

Charitos, Karadanos, Sereti, Triantafillou, Koukouvinou and Martakos (2000), developed a scenario (“Returning Home”) in a virtual environment, which aided the organization of autistic children's behaviour in a series of everyday activities. The application provided the opportunity to adjust to each individual functioning level. Additionally, it provided two modes of functionality, corresponding to individuals with a lower or a higher level of functioning autism. The first mode is relatively passive, the participant only need to press a button for triggering the next sequence of activities. The second mode is more active; the participant can navigate within the virtual environment and interact with 2D or 3D objects. Educators select among a series of certain sequence of activities to be presented to the participant in a certain order. A virtual animated character demonstrated some everyday activities in a house after the child arrives from school. No results were reported at the time since the application was at the development stage (Charitos, Karadanos, Sereti, Triantafillou, Koukouvinou, Martakos, 2000).

Strickland, McAllister, Coles, Osborne (2007), investigated whether children with ASD would use VR equipment and whether they could learn in a virtual environment. The VR system consisted from a head-mounted display, body trackers, and three-dimensional hand controls. Participants were two children (a girl and a boy, 7 and 9 years old) and were placed in a street crossing virtual scene to learn two basic steps of stopping at a stop sign and tracking moving cars before crossing a street. Before exposure, neither child displayed awareness of street boundaries or demonstrated normal safety actions. While in the virtual environment both children immersed themselves in the scenes, verbally labelled objects and colours of objects, moved their bodies when tracking a moving car, and located a stop sign. The parents of the girl indicated that she did track moving cars in the real world with her head after VR training (D. Strickland, D. McAllister, C. Coles, S. Osborne, 2007).

Parsons and Cobb (2011) refer to studies which suggest that children can learn information from VR and some can transfer this knowledge to the real world. Strickland (2007) developed desktop VEs to teach fire safety skills, like how to recognize the fire danger and how to respond. Eleven out of the 14 children who took part completed the VE session without error. An animated character named Buddy demonstrated proper actions and continually interacted with the child. A correct action followed by a jumping from Buddy and a "Good Job". If the child walked into a fire the screen went black and a "Try again" was sounded (D. Strickland, D. McAllister, C. Coles, S. Osborne, 2007). Self (2007) developed a fire safety and tornado safety VR training application. Children were able to use the program successfully, but the responses of children varied widely and there was limited evidence of generalization of understanding to real fire and tornado situations. Furthermore, Josman (2008) tested VR as a tool for teaching children with autism to cross the road safely. The results showed that children could use the VE successfully and improve their skills to cross a virtual street during the study. Some of them were able to transfer this learned knowledge to a real street. The authors emphasized that programs need to be carefully targeted according to the individual needs of children (S. Parsons, S. Cobb, 2011).

Parsons and Cobb (2011) stated that nevertheless, the overall scale of the research about VR for educational purposes generally (and supporting social skills specifically), is undeniably limited. Because of the limited scale of research the results characterized as equivocal. The challenge is to translate the VR applications into flexible, workable, useful and realistic tools for everyday classrooms. Also, another challenge is to design learning applications that provide the most effective combination of the features of VR technology (integrate VR with digital media) to support the required learning, to be educationally appropriate and useful. The authors refer to an interesting find that the more realistic a virtual environment, the more generalization will be achieved, because the scene is more 'believable', and, therefore, skills and understanding are more likely to be transferred from the virtual to the real world (S. Parsons, S. Cobb, 2011).

Despite the vast body of already existing research about VR for educational purposes for children with autism there are still missing references about the use of VR CAVE environments for this purpose. The scale of the research about VR CAVE environments in educating children with autism is limited, and that's why we propose this research. This research seeks to investigate the use of VR CAVE environment for the enhancement and improvement of social skills and behaviours for children with autism.

2. Methodology

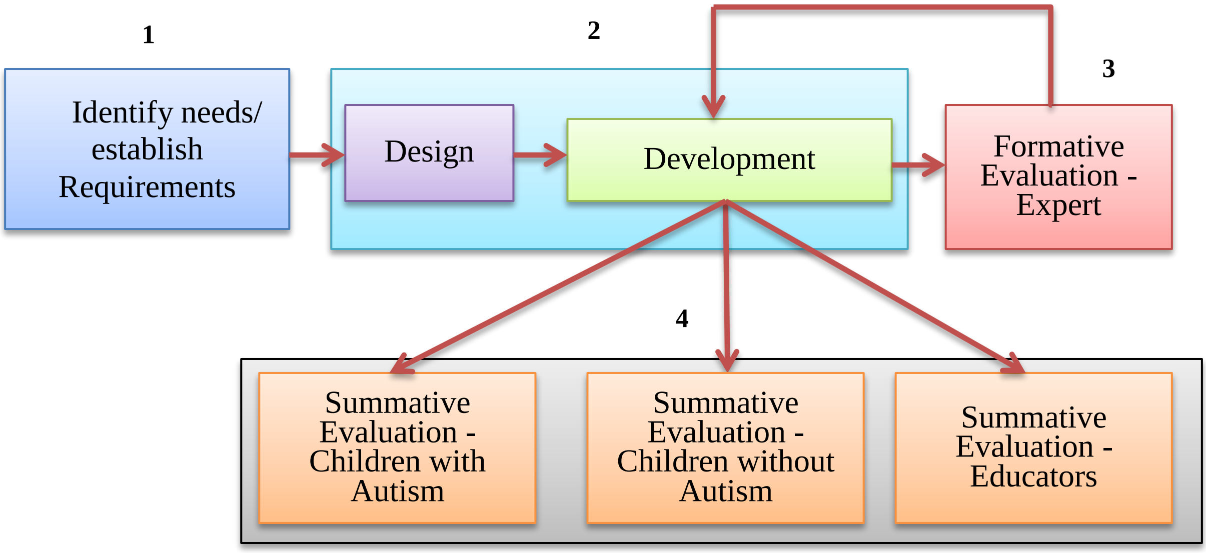


Figure 2: Steps of the Methodology

The steps followed in achieving the results of this research, are presented in Figure 2, and described below:

2.1 Step/phase 1: Identify needs/ establish Requirements

As a first step of the methodology, the system requirements needed to be established. A simple study was carried out to discover the requirements of the system users. To gather data, for requirements a structured interview was conducted with an educator of children with autism. Some topics that were discussed during the interview were the training-treating methods currently used in the training of children with autism, in which areas the education of children with autism focused, what is the relationship of children with autism with technology. What should be taken into account when training children with autism, what are the problems or difficulties that children with autism have to deal with? What are the problems or limitations of existing methods of treatment? Did they use technology in educating children with autism? How technology could help in educating children with autism? How they see the future of the training, what needs to be changed?

With this interview the system requirements were established. We identified important aspects of the system that should be taken into account and possible approaches or scenarios that might be implemented for the training of children with autism. The approach discussed most was the possibility of training children with autism about specific social skills and behaviours in a Virtual Reality environment especially for unsafe situations. We discussed some scenarios where the child could interact within a safe VR environment and learn how to act in some unsafe situations in the real world.

2.2 Step/phase 2: Design and Development

After we identify the needs and requirements we proceeded to the design and development phase. At this phase we decided the scenario that would be implemented and started developing the scenario that will be executed during the training process according to the requirements of the system users.

2.3 Step/phase 3: Formative Evaluation

During the third phase a formative evaluation was conducted with the help of one of the educators of children with autism (expert) in order to provide guiding feedback for the proper completion of the application. For the data gathering we used a combination of methods, structured interview and the think aloud method.

During this phase important issues were reported and features of the application were clarified in order to be considered suitable for the training of children with autism. This phase was followed by the final stage of the implementation (design and development phase), according to the feedback that was collected.

2.4 Step/phase 4: Summative Evaluations

Phase 4 refers to the summative evaluations that were conducted in order to achieve the results of this research. The method we used was usability testing. The summative evaluation of this research was divided into three different evaluations: first an evaluation that was conducted with children without autism, a second evaluation with educators of children with autism and finally an evaluation with children with autism. The data collection on usability testing was achieved with a combination of methods – observation and questionnaires.

3. Design & Development

3.1 Software

For the design and development of the immersive application in the VR CAVE environment we used the EON Studio Professional for the implementation, Autodesk Maya and 3ds Max for the 3D modelling and animation production. For the implemented scenario ('Lost in City') a road-crossing learning environment was developed. In this environment, there is a crossing, with the crossing button, lights and cars that commute in a street of a city (see Figure 3). The child has the opportunity to navigate and interact with the virtual world. The child can press the button at the crossing, wait until cars stop and lights change from red to green and then cross the street.

Figure 3: A scene of the crossing learning environment.

3.2 Equipment

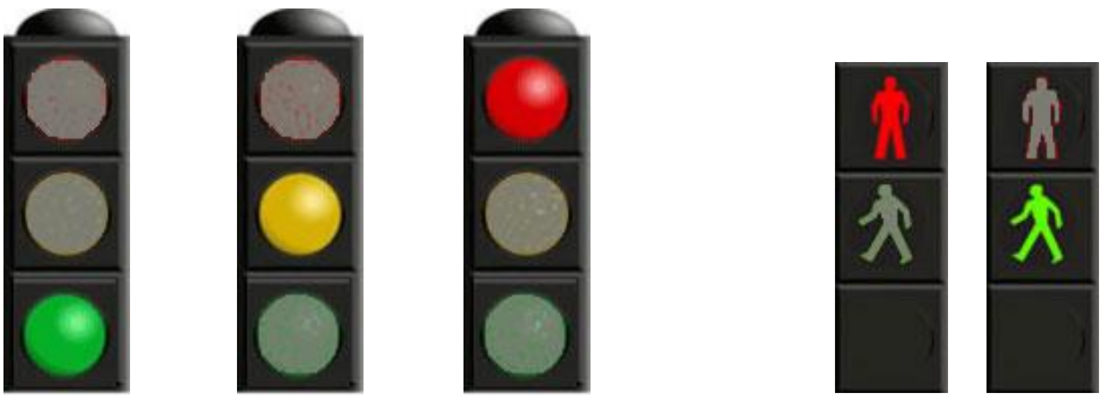
The EON REALITY iCube VR CAVE environment was used to run the application and present the 3d virtual world, the 3D glasses which the participant wears, and the xbox controller that the participant or educator uses for the interaction and the navigation in the virtual environment. The participant entered the VR CAVE and interacted with the virtual environment through the 3D glasses and the xbox controller. Both 3D glasses and xbox controller have markers on them so that the position and direction of them could be detected. In this way the virtual environment adjusted according to the participant's head movements. For example, if the participant moves his head to see beyond a wall then the virtual environment will be adjusted properly. Also, with the 3D glasses, the participant will be able to see in three dimensions the virtual world. The xbox controller was needed for the navigation and interaction in the 3D virtual environment (e.g. navigates and selects objects in the scene). The VR CAVE consists of four HD screens, four projectors and cameras. The screens are placed in such a way that created a box without a roof and front part (See Figure 4). The participant when using the VR CAVE is within this and with the help of the glasses can see the virtual world in three dimensions, all this makes the user fully immersed in the virtual environment.

Figure 4: VR CAVE, glasses, xbox controller.

3.3 3D Modelling and Animation Production

For the 3d modelling and animation production we used the software Autodesk Maya 2013. With Autodesk Maya 2013 we modelled the road, the crossing, the lights, and the crossing box with the crossing button. Also we imported models of realistic cars of different types, and we animated them in order to commute in the street of the city. Furthermore we animated the lights at the crossing which were aimed at drivers to alternate from green colour to orange and then to red colour and vice versa (see Figure 5 (a)). Also we animated the lights at crossing that were aimed at pedestrians to change from red to green (see Figure 5 (b)).

The crossing learning environment was designed and developed to be used by children with autism. For this reason we made some animation that would help children to focus during the session, to understand some activities and to make the connection between virtual and real world easily. In this way specific actions would become more obvious and understandable to the child. First of all, we made an animate hand which represents the action ‘pressing the button’ at crossing when we want to cross the street safely. When the child presses the button simultaneously the virtual hand will perform the same action at the virtual world (see Figure 6). Secondly, we produce an animation of the lights that will help the child to focus at red lights, and to understand that he/she must wait. More specifically, to show visually to the child that he must wait when he press the button at the crossing box, lights move right from their start position and then zoom in and out (see Figure 7). When the cars stop the pedestrian lights go back to their start position and change colour from red to green, and then the child will be able to cross the street (see Figure 8).



(a) (b)

Figure 5: (a) lights at the crossing which aimed at drivers, (b) lights at crossing that aimed at pedestrians

Figure 6: virtual animate hand perform the action 'press crossing button'

Figure 7: lights animation, move right, zoom in – out

Figure 8:

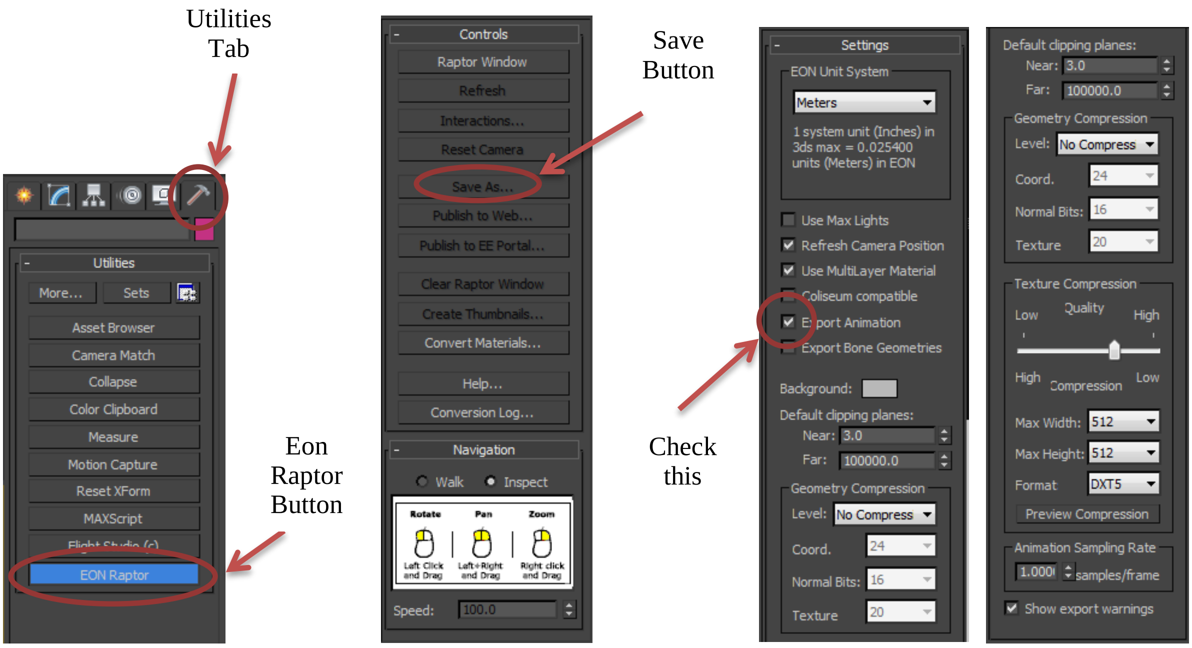
cars stop, lights go back to start position and change from red to green, child is able to cross the street.

3.4 Import Models and Animations to EON Studio Professional

In order to import 3d models and animations to EON Studio Professional, we have to follow a specific procedure. First of all, we installed the EON Raptor for 3ds Max. EON Raptor for 3ds Max is a plugin that allows exporting 3d models and animations from 3ds Max to EON Studio. More specifically this plugin allows saving a scene from 3ds Max in the file format (.eoz) that is appropriate for Eon Studio Professional. Because the 3d modelling and animation, was developed in Maya, we needed to send our scene, or specific models and animations as a new scene to 3ds Max.

When the new scene is open in 3ds Max:

1. Click on utilities tab, that is at the top right of the screen (see Figure 9 (a))
2. Then click on EON Raptor button (see Figure 9 (a))
3. At ‘Settings’ section that appears, click on ‘Export Animation’ check box (see Figure 9 (c)) – if you want to export animation, otherwise if you only need to export a model without animation do not check it.
4. At ‘Controls’ section that appears, click the ‘Save as’ button (see Figure 9 (b))
5. Give a name to your .eoz file and click save



(a) **(b)** **(c)**

Figure 9:

(a) Utilities tab and Eon Raptor Button

(b) Raptor Controls: click save as button

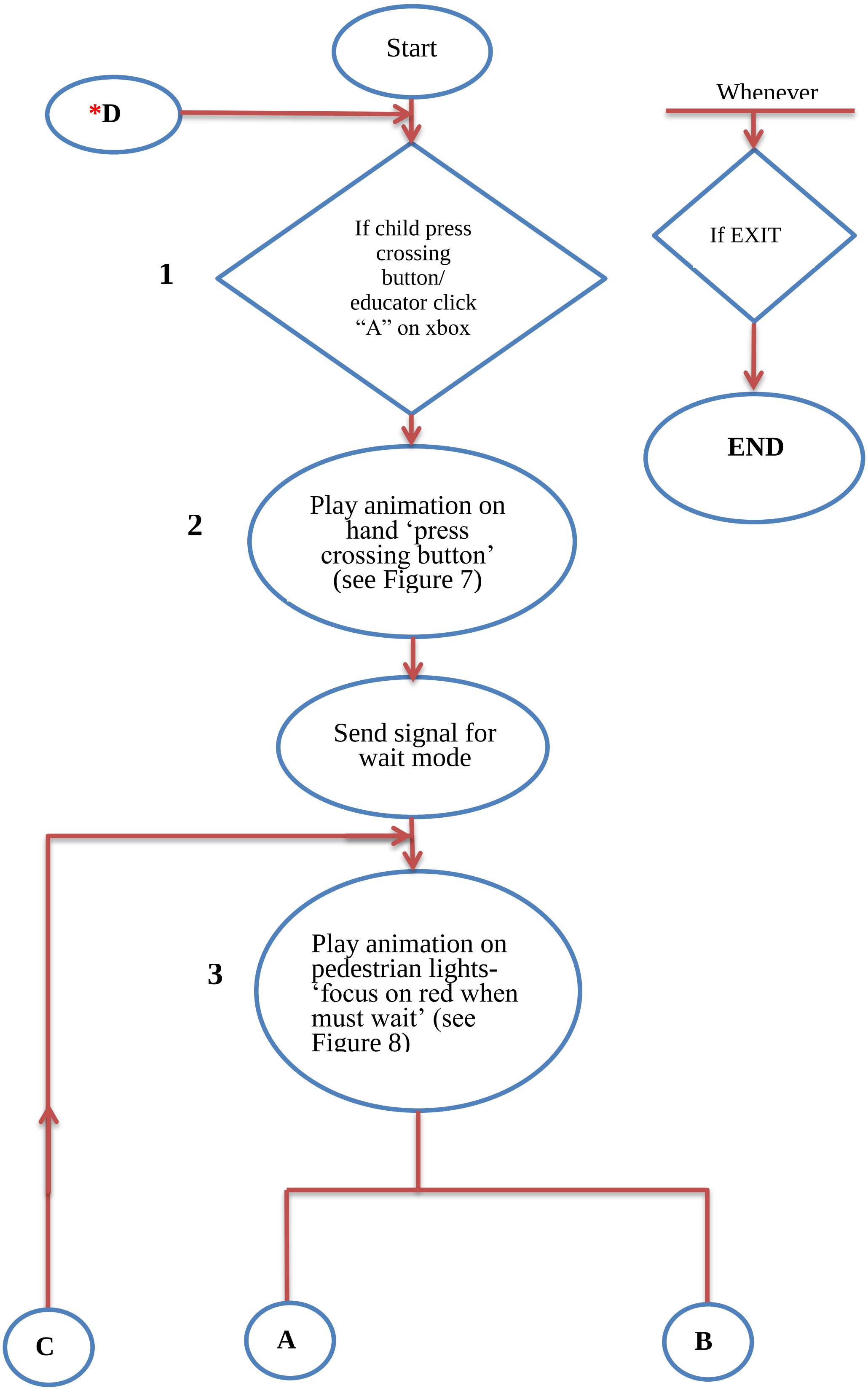
(c) Raptor Settings: Check the export animation

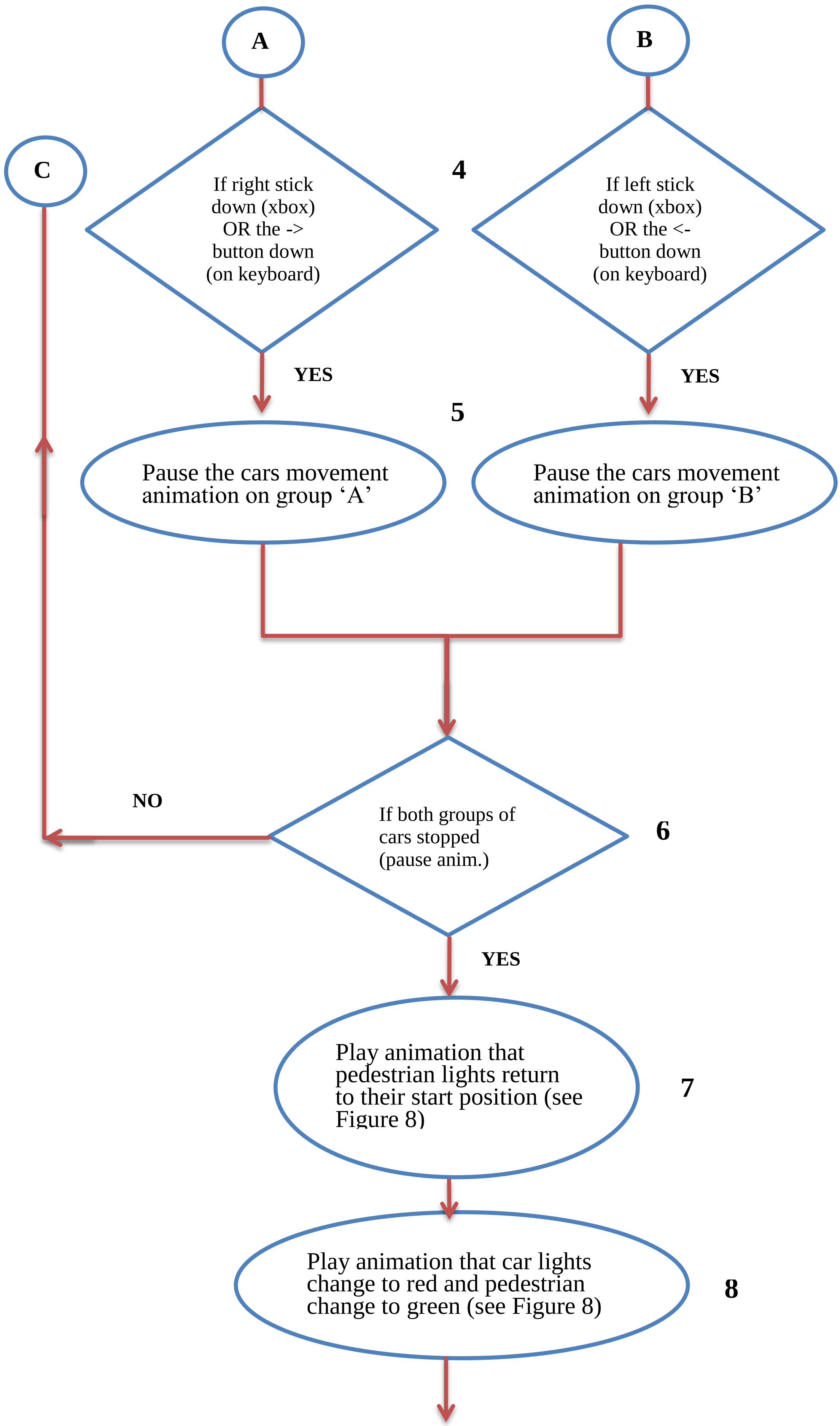
The .eoz file is a file that has stored the models and animations in a format that is appropriate for EON Studio Professional. After that you can open the file in EON Studio Professional and edit it, implemented it or adjust it according to the purpose of your program.

Note that for Eon Studio Professional 7 you need to use 3ds Max 2010, but for Eon Studio Professional 8 you need to use 3ds Max 2013 and the relevant Eon Raptor Plugin. In this way you can export models and animations properly without problems.

3.5 Visualization of state diagram

Below a state diagram shows the logical flow of the application in the VR CAVE environment, which was implemented (see Diagram 1).


Start
*D
Whenever
1
If child press crossing button/ educator click "A" on xbox
If EXIT
END
2
Play animation on hand 'press crossing button' (see Figure 7)
Send signal for wait mode
3
Play animation on pedestrian lights- 'focus on red when must wait' (see Figure 8)
C
A
B



A
B
C
If right stick down (xbox) OR the -> button down (on keyboard)
4
If left stick down (xbox) OR the <- button down (on keyboard)
YES
YES
5
Pause the cars movement animation on group 'A'
Pause the cars movement animation on group 'B'
NO
If both groups of cars stopped (pause anim.)
6
YES
Play animation that pedestrian lights return to their start position (see Figure 8)
7
Play animation that car lights change to red and pedestrian change to green (see Figure 8)
8

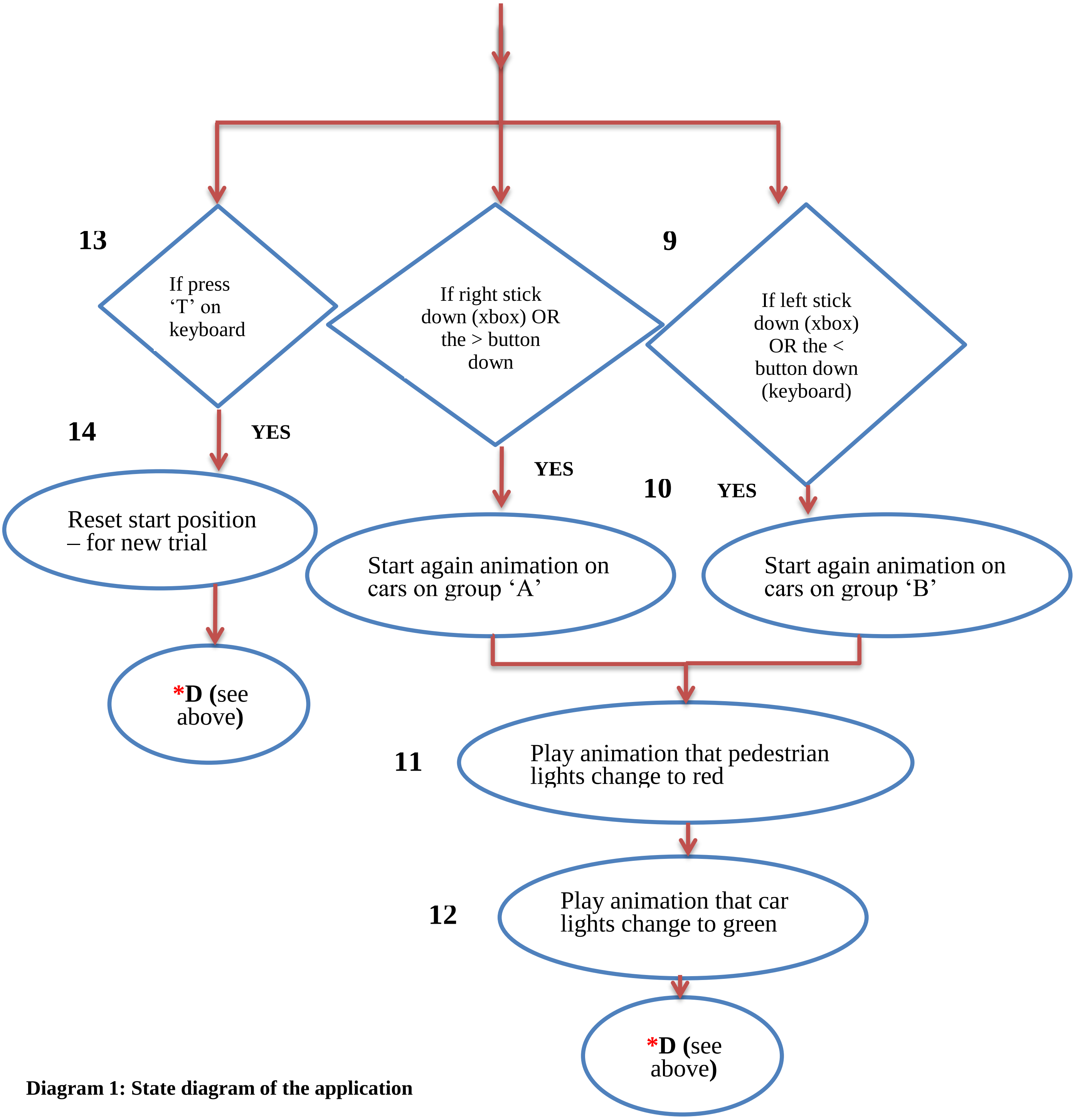


Diagram 1: State diagram of the application

3.6 Development in EON Studio Professional

Eon Studio Professional is the software which is necessary in order to develop and implement applications that can run in EON REALITY iCube VR CAVE environment. Eon Studio Professional combines programming (Javascript) and visual programming. In Figure 10 you can see the view of the main features and windows in Eon Studio Professional.

At Figure 10 (a) we see the Simulation Tree – the tree where the scene, camera, 3d objects, animations, etc. should be placed in order to be placed in the simulation. Each object in the simulation is called a node. In Figure 10 (b) you can see the Node Window that is a list with all nodes that Eon Studio offers. In Figure 10 (c) you can see the Routes Window where all the connections between the nodes can be made in order to develop the main program. In this window we can make connections in order to make an interaction in the program, or play an animation, etc. In Figure 10 (d) you can see the Property Bar; the bar with the properties of each object – node in the simulation.

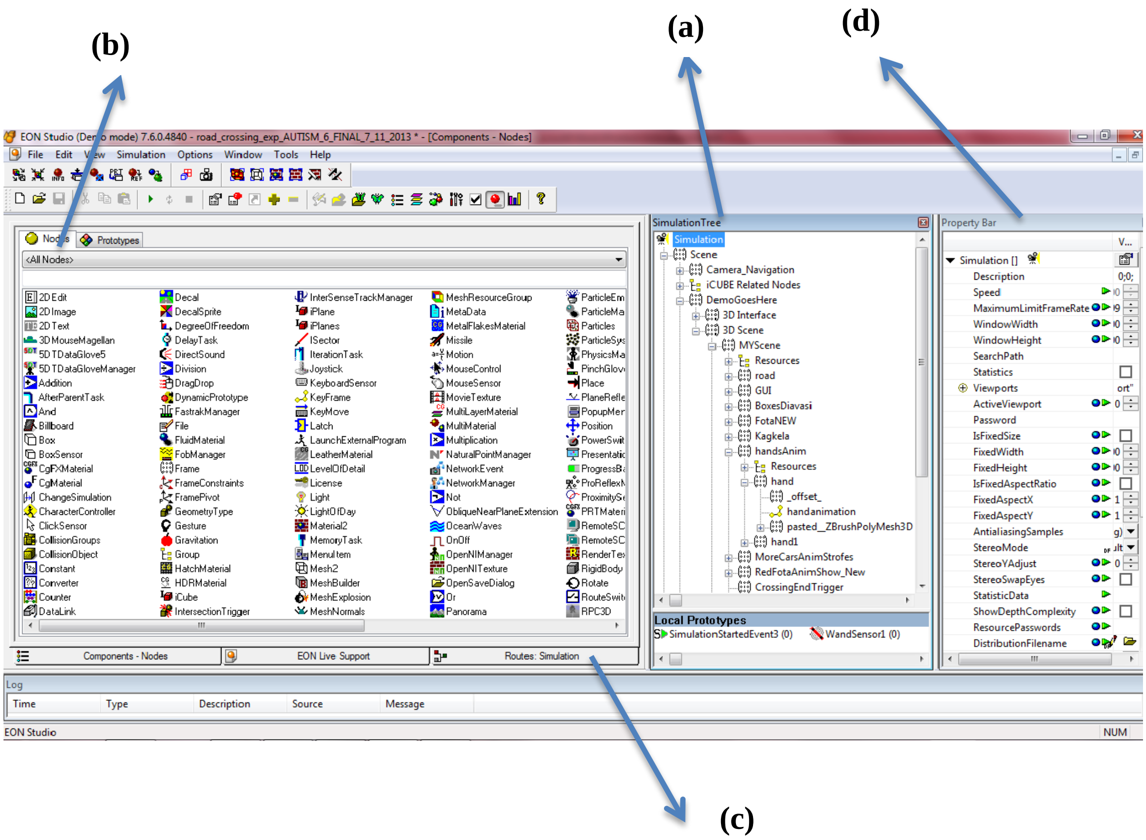


Figure 10:
(a) Simulation Tree
(b) Node Window
(c) Routes Window
(d) Property Bar

The main features of the application will be explained below, and how these were implemented in Eon Studio Professional. The main features of the application that will be explained correspond at each state of the state diagram that was presented above (see Diagram 1).

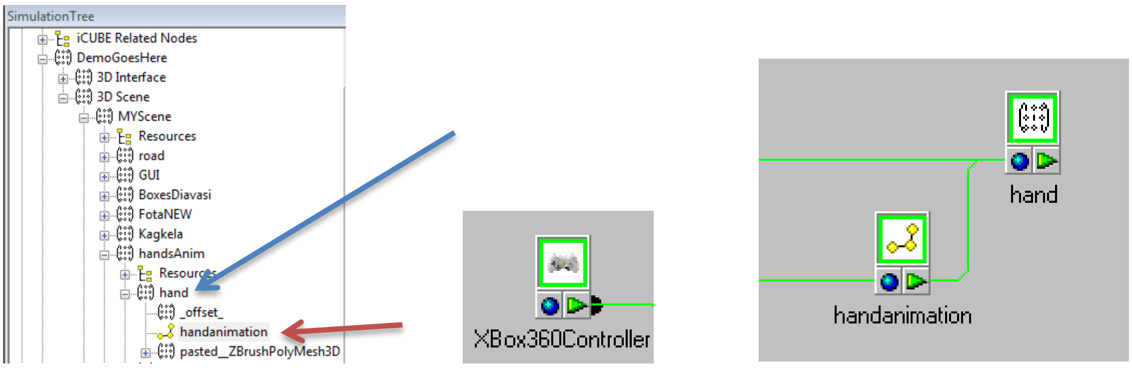
3.6.1 Child press the crossing button

Algorithm

If the child presses the crossing button then: (see Diagram 1, **state 1**)

(a) The educator press the 'A' button on xbox (see Diagram 1, **state 1**)
(b) Play animation on hand 'press crossing button' (see Diagram 1, **state 2**)
(c) Play animation on pedestrian lights-'focus on red when must wait' (see Diagram 1, **state 3**)

Implementation on Eon Studio



(a) **(b)**

Figure 11: (a) Place the 3d model 'hand' and the animation of hand 'handanimation' in proper place at simulation tree
(b) Connections on routes window

As we explained before every 3d model or animation was designed and produced in order to be used in EON Studio Professional, it can be opened in the Studio if it is saved as an .eoz file. After that we can put the models and animations in our scene as nodes if we place them in the proper place in the Simulation Tree of our Simulation. For example as you can see for the hand and the animation of hand in Figure 11 (a).

At Figure 11 (b), we see the connections that were made in the Routes Window in order to implement the procedure at step (a) and (b) of the Algorithm, i.e. ‘When click ‘A’ button on xbox controller play the animation on hand’.

Connections on Routes Window

- Xbox controller (when A button down) => hand (set visible)
- Xbox controller (when A button down) => hand animation (‘Active’ - play)
- Hand animation (when is over) => hand (set invisible)

At Figure 12, we see the connections that were made in the Routes Window in order to implement the procedure at step (c) of the Algorithm (‘focus on red when must wait’).

Connections on Routes Window

- Xbox controller (when A button down) => move left animation (play)
- move left animation (when is over) => zoom in out animation (play)

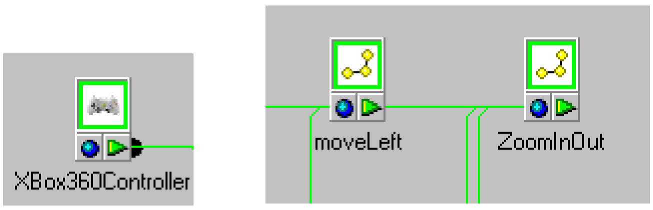


Figure 12: Connections on routes window

3.6.2 Stop the cars

Algorithm

If the right/left stick on xbox is down OR the ->/<- button on keyboard is down: (see Diagram 1, **state 4**)

- Pause the animation of movement on group A/B of cars (see Diagram 1, **state 5**)

Implementation on Eon Studio

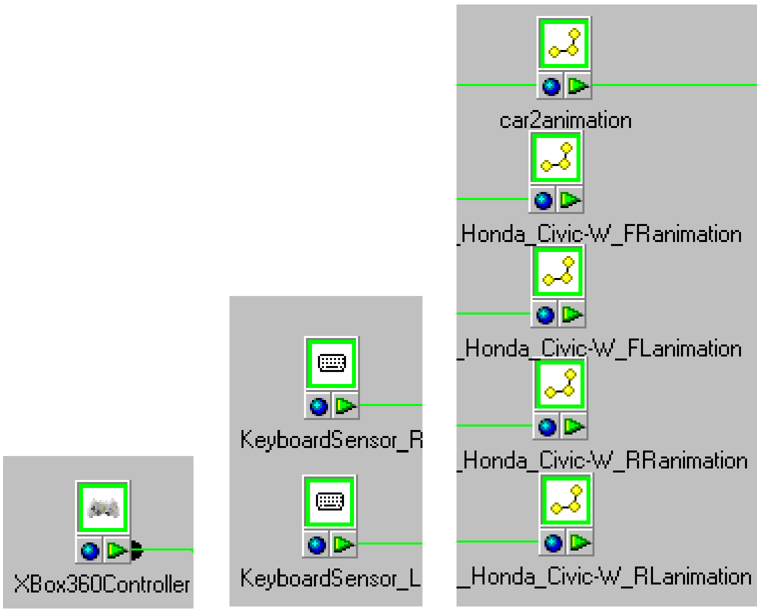


Figure 13: Connections on routes window

At Figure 13, we see the connections that were made in the Routes Window in order to implement the procedure at Algorithm. At Figure 13 we can see the connections that were made in one of the cars and the wheels of it. In the same way we made the connections for all cars used in the scene (both for group A and B of cars).

Connections on Routes Window

- Xbox controller (when right/left stick down) => cars and wheels animation on group A/B (pause – pause toggle = true)
- Keyboard (when ->/<- is press) => cars and wheels animation on group A/B (pause - pause toggle = true)

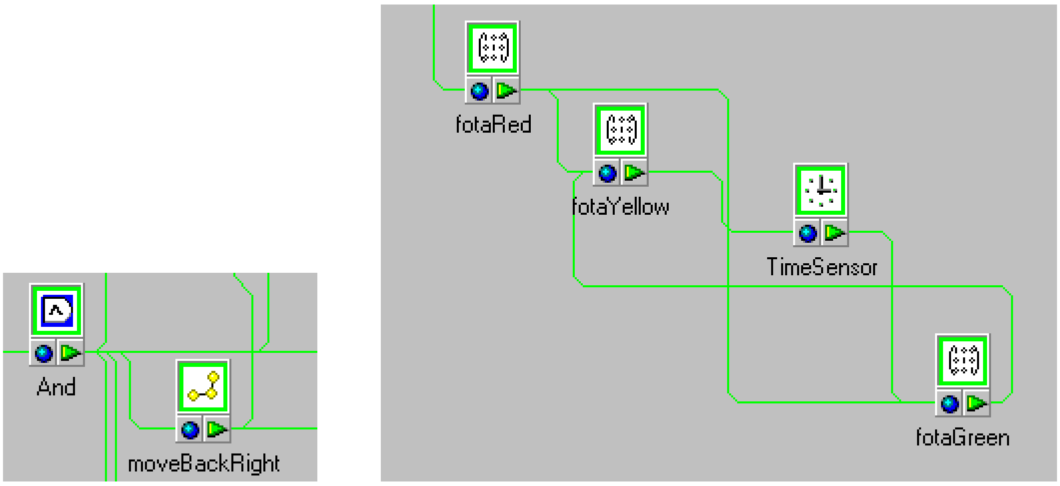
3.6.3 Pedestrian lights change to green and the lights aimed at drivers change to red

Algorithm

If both groups of cars (A and B) have stopped (see Diagram 1, **state 6**)

- Play animation that pedestrian lights return to their start position (see Diagram 1, **state 7**)
- Play animation that pedestrian lights change to green and lights that aimed at drivers change to red (see Diagram 1, **state 8**)

Implementation on Eon Studio



(a) **(b)**

Figure 14: Connections on routes window

(a) Connections on pedestrian lights animation, return to their start position

(b) Connections on pedestrian lights animations change to green and lights aimed at drivers change to red

At Figure 14, we see the connections that were made in the Routes Window in order to implement the procedure at Algorithm. At Figure 14 (a) we can see the connections in order for the pedestrian lights to return to their start position. In Figure 14 (b) we see the connections that enabled the animation in which the pedestrian lights change to green and the lights aimed at drivers change to red.

Connections on Routes Window

- Logical AND node (when true – when both group of cars stopped) => pedestrian lights animation return to start position (play).
- Logical AND node (when true – when both group of cars stopped) => pedestrian lights with colour red (set invisible)
- pedestrian lights with colour red (when is invisible) => lights yellow (set visible)
- lights yellow (when is visible) => time sensor (wait for 1 second)
- time sensor (after 1 second) => pedestrian lights with colour green (set visible)

3.6.4 Start again cars animation

Algorithm

If the right/left stick on xbox is down OR the ->/<- button on keyboard is down: (see Diagram 1, **state 9**)

- Play again the animation of movement on group A/B of cars (see Diagram 1, **state 10**)

Implementation on Eon Studio

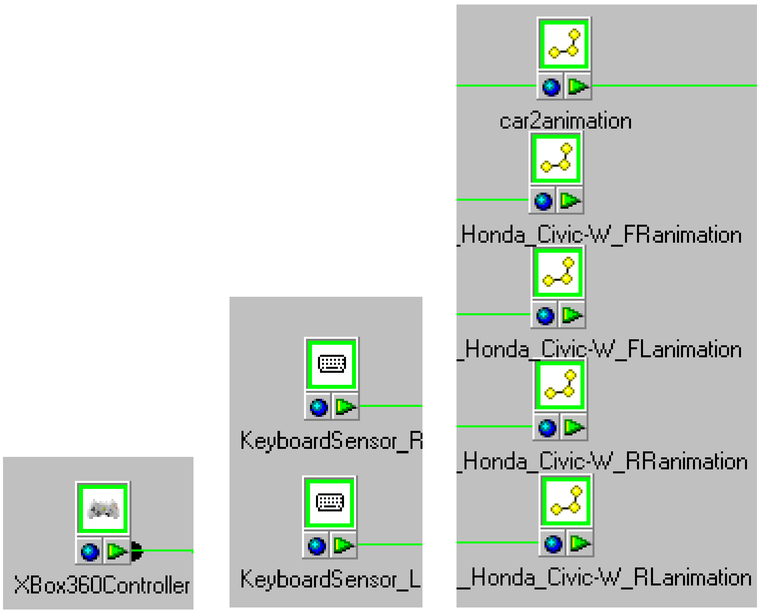


Figure 15: Connections on routes window

At Figure 15, we see the connections that were made in the Routes Window in order to implement the procedure at Algorithm. At Figure 15 we can see the connections that were made in one of the cars and the wheels of it. In the same way we made the connections for all cars in the scene (both for group A and B of cars).

Connections on Routes Window

- Xbox controller (when right/left stick down) => cars and wheels animation on group A/B (start again – pause toggle = false)
- Keyboard (when ->/<- is press) => cars and wheels animation on group A/B (start again - pause toggle = false)

3.6.5 Pedestrian lights change to red and the lights aimed at drivers change to green

Algorithm

If one of the two groups of cars (A/B) start again (see Diagram 1, **state 9 - 10**)

- Play animation that pedestrian lights change to red (see Diagram 1, **state 11**)
- Play animation that lights that aimed at drivers change to green (see Diagram 1, **state 12**)

Implementation on Eon Studio

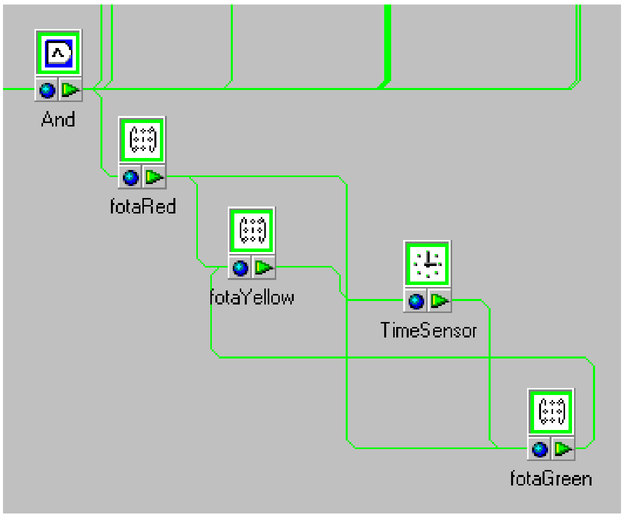


Figure 16: Connections on routes window - pedestrian lights back to red and lights aimed at drivers change to green

At Figure 16, we see the connections that were made in the Routes Window in order to implement the procedure in Algorithm. At Figure 16 we see the connections where pedestrian lights change to red and the lights aimed at drivers change to green.

Connections on Routes Window

- Logical AND node (when false – when at least one of the cars starts again) => pedestrian lights with colour red (set visible)
- pedestrian lights with colour red (when is visible) => pedestrian lights with colour green (set invisible)

3.6.6 Reset for a new Trial

Algorithm

If 'T' button is pressed on keyboard (see Diagram 1, **state 13**):

- Initialize user start position for a new trial (see Diagram 1, **state 14**)

Implementation on Eon Studio

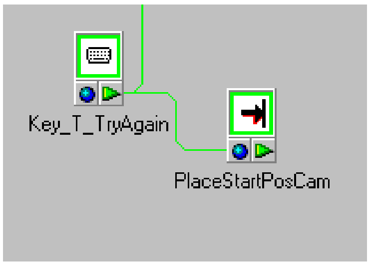


Figure 17: Connections on routes window – New trial – place the user on start position

At Figure 17, we see the connections that were made in the Routes Window in order to implement the procedure in Algorithm. At Figure 17 we see the connections in order to start a new trial. When 'T' on keyboard is pressed, then the user is placed in the initial / start position.

Connections on Routes Window

- Keyboard (when 'T' is press) => Place node (set active)

The Place node is used when we want to place a node at a specific position. In this case we want to place the camera node to the initial /start position.

3.7 Screenshots of the application in the VR CAVE environment

Next we present some screenshots from the application in the VR CAVE environment that was implemented, for the training of children with autism about how to cross the street safely.

In Figure 18 the scene is presented where the cars commute in a virtual road.

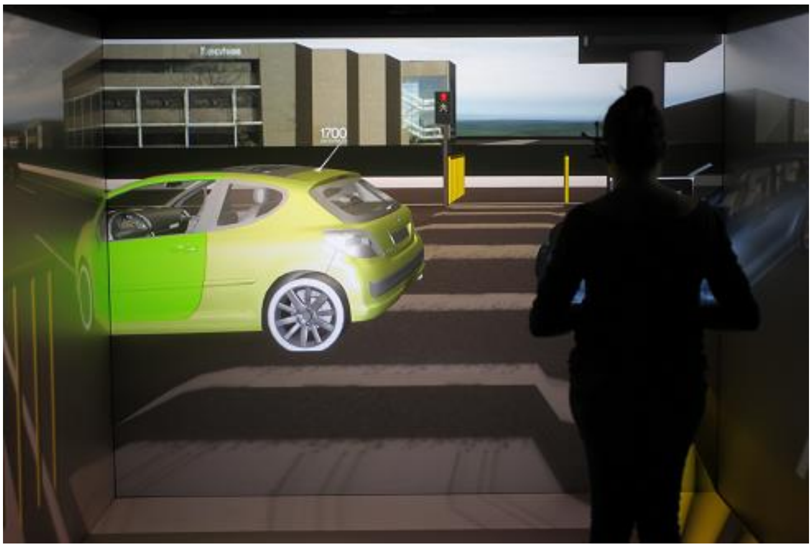


Figure 18: Cars commute in a virtual road

In Figure 19 the user presses the crossing button and the animation on lights is activated that helps the user to understand that he/she must wait.

Figure 19: User presses the crossing button

In Figure 20 the cars have stopped at the crossing and the pedestrian lights change from red to green, the user is able to cross the road. In Figure 21 the user crosses the road.

Figure 20: Cars stopped and pedestrian lights change from red to green

Figure 21: User crosses the road

4. Evaluation, Results and Analysis

4.1 Executable scenario

The goal of this research is to design and develop an immersive application in a VR CAVE environment for educating/treating children with autism. The main goal of the project is to provide a tool for children with autism which can help enhance and improve their social skills and behaviours. The training focused in real life situations which are difficult or impossible to explain to children with the known methods of treatment. For example, an unsafe situation or a situation where the child must experience it, in order to learn how to act e.g. crossing the road or avoiding moving cars.

The treatment focused on situations where the child will be alone and helpless in an unknown place. Specifically, we developed a scenario where the child wonders off in the city and losses his/hers parents ("Lost in city"). Possibly he/she will not know how to react or what to do in order to find his attendants. He/she should be prepared to stay calm and act accordingly. In the scenario of the city it is extremely dangerous because of the cars. The child should learn how to cross the road safely, identify and avoid cars, recognize and press the crossing button and recognize and interpret the lights. The training on the scenario is split into various parts so that the child builds step by step the knowledge which is necessary in order to cope with the next part of the treatment. In this way new knowledge will be "digested" better and easier and the learned skills could lead to new abilities.

The parts of the training scenario, "Lost in city", are executed as follows:

- The child is trained to recognize, track, and avoid the moving cars within the virtual street scene
- The child is trained to recognize and find the crossing button, walk to it, stop, and press it
- The child will learn to recognize the lights and to interpret them (red light means stop and green walk)

- The child is trained to recognize the crossing and walk to it if he/she can – according to the lights and cars
- The final phase was the most difficult; the child has to cross the street alone without any help. The session was executed from the beginning and the child crossed the street alone.

Figure 22 shows the user in the VR CAVE with the scenario ("Lost in city"). The user can navigate and interact within the virtual environment, press the button at the crossing (see Figure 23) and wait until cars stop and pedestrian lights have changed from red to green (see Figure 24) and then cross the street (see Figure 25).

There are two types of users using the application during the session: the child and the educator. The educator has an important role, because he stands next to the child during the session and handles the session. The educator should give instructions to the child and try with the help of the system to transfer knowledge about how to cross the road safely. He should be guiding the child, and giving him/her instructions about the activities he/she should perform at each part of the session. Moreover, he/she should explain to the child the errors that he/she made in order to avoid repeating them again and show the right way of doing things. Also, the educator can reward children who perform a correct action, activity or complete each part of the session or the whole session. In addition, the educator handles the xbox controller, in order to send signals to the application e.g. stop cars. The functionalities offered by the xbox controller and the instructions on how the educator can use it are explained in Figure 26.

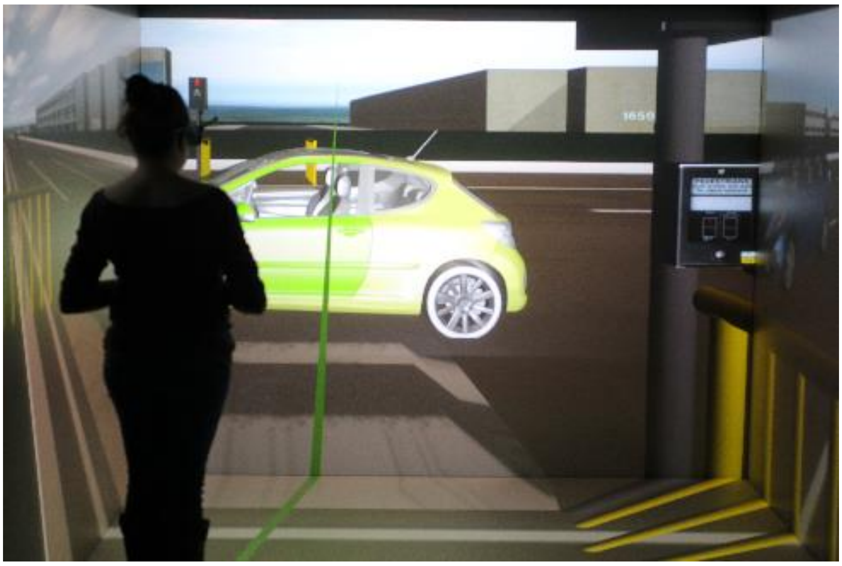


Figure 22: User in the VR CAVE with the first scenario.

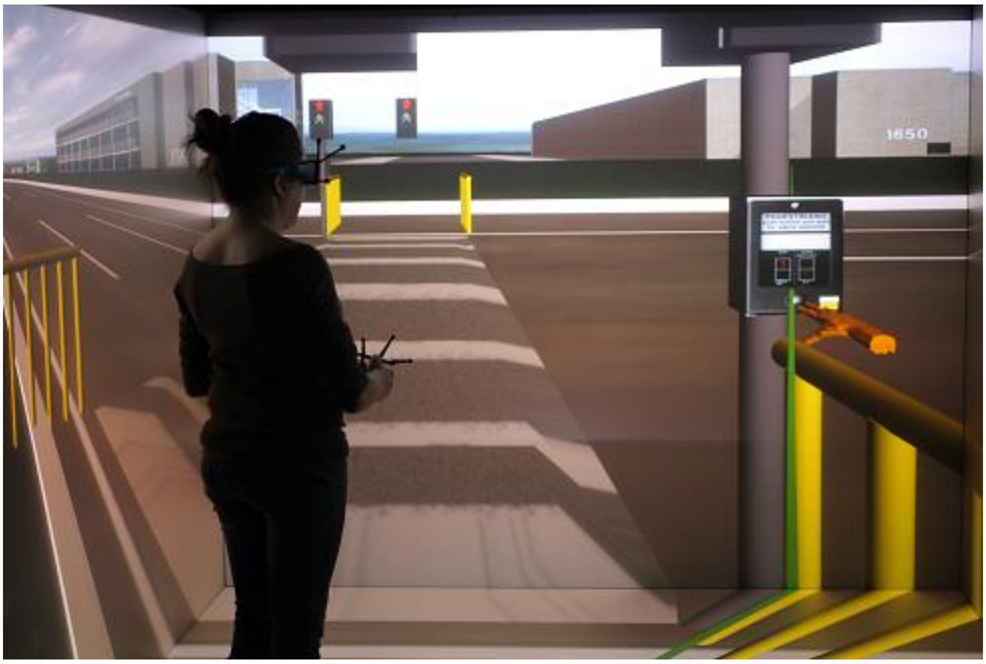


Figure 23: Action – press crossing button

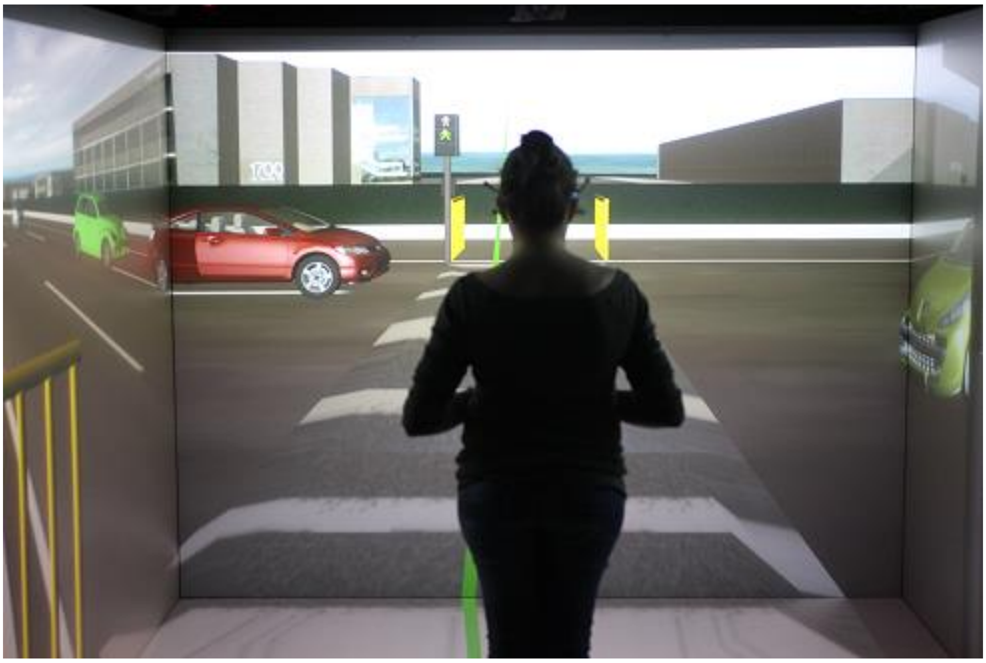


Figure 24: cars stop and pedestrian lights changed from red to green

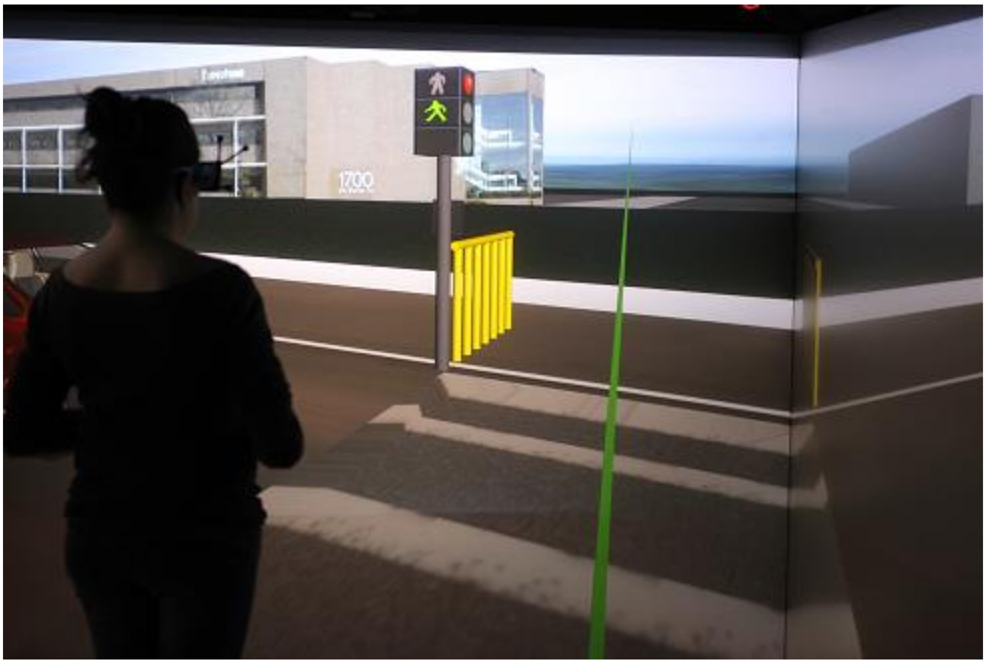


Figure 25: Action – cross the street

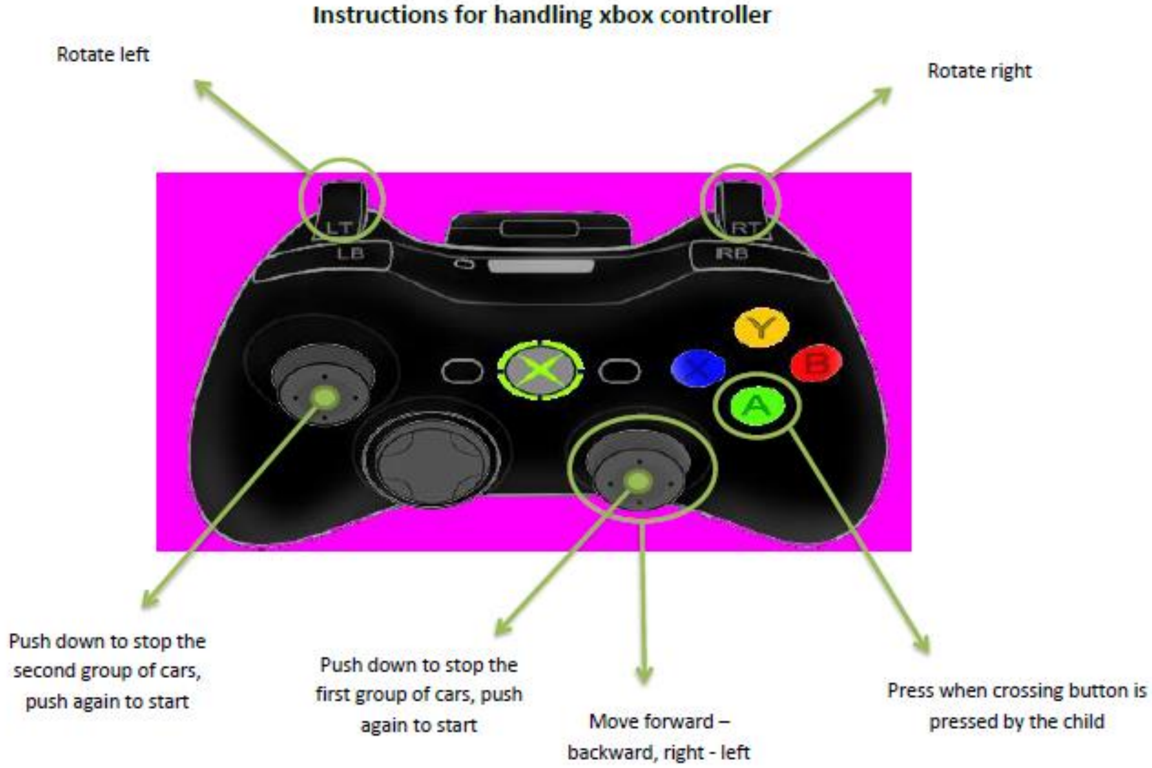


Figure 26: Instructions for handling xbox controller

4.2 Evaluation Methods

During the development process of the application a first formative evaluation was conducted with one of the educators of the Cyprus Autistic Association. This first evaluation was conducted in order to provide guiding feedback for the proper completion of the application. We also had the opportunity of conducting a second empirical evaluation towards the end of the development phase with the participation of twelve children (9-10 years old) without autism. This evaluation helped us to evaluate the application as a learning tool for children, and to understand important features which must be identified during a session in order for the training to be correct, complete and effective. These features should be taken into account in the training of children with Autism.

As this application is an interactive system, user studies were appropriate, to assess whether the project was successful. The evaluation we hoped to perform, as a summative evaluation, was an empirical evaluation using children with autism. We hoped that a number of children with ASDs would have a session using the application in a VR CAVE environment for the training of specific social skills. The engagement and the use of the application by children during the session would be measured which would provide an insight of the effectiveness of the application. All the procedures required for the organization and realization of this summative evaluation, were performed. Unfortunately, none of the parents of children with autism responded positively or allowed to the proposal for the participation of their children as part to the process of the evaluation of the application.

To overcome this obstacle, we decided to proceed with a second plan. For the summative evaluation, we conducted another empirical evaluation with the participation of educators, who specialize in education of children with autism. As they specialize in the education of children with autism they were able to evaluate the system as a learning tool for children with autism. Furthermore, they were able to evaluate whether it could be used in order to enhance and improve the social skills and behaviours of children, especially in learning how to cross a road safely.

4.2.1 Formative Evaluation - Educator – expert evaluation

The first evaluation of the application was conducted with the help of one of the educators of the Cyprus Autistic Association in order to provide guiding feedback for the proper completion of the application. The educator used the application, interacted with it and was introduced to the features and capabilities of the up-until then developed application. Further, the procedure to be followed during the training was explained to him, the scenario that would be executed as well as the various parts that the scenario was split into. After that, the educator was able to provide us with his opinion about the application, note down any issues, and mention anything he considered as important. Additionally, he clarified any existing queries or questions that we had about the features of the application in order to be considered suitable for the training of children with autism.

With this formative evaluation important information was collected for the proper implementation of the application. An important issue that was discussed concerned the way a child should be given to understand that he made a mistake, or that he/she successfully completed a task. Initially we played a sound which corresponded to each case separately.

The educator urged us not to follow this approach because sounds like that often disorientated and confused children. Also he/she mentioned that the best way to explain to a child with autism that he/she made a mistake or he/she successfully completed a task is to hear it directly from the educator. For example if the child has completed a task successfully the educator should say "Well done!", "Bravo" or "Nice job". On the other hand if the child made a mistake the educator should say "Let's try again". Furthermore, the educator must explain to the child what the mistake was in a way that the child will comprehend it and not repeat it.

In addition, we repeated the scenario ("Lost in city") in two different types of virtual worlds, which vary in their configuration. The first type of virtual world is more simplified, without a lot of details and objects in the scene (e.g. one road with two cars, no or few buildings, without objects). The second type of virtual world is more realistic, with details and objects in the scene (e.g. a lot of buildings, cars, and other objects). We wanted to consider each child individually, in which type of virtual world he/she could focus and concentrate better and interact within it in a meaningful way. Regarding this approach the educator mentioned that the training is better to be executed only in the second type of virtual world, which is more realistic. The second type of virtual world is more close to real life, and it is possible the child will identify it in everyday life. This could help the child to generalize and transfer the new knowledge to the real world. On the contrary the first type of virtual world will not help or benefit the child, because it portrays a scene that the child will never see in the real world. This is why it would be difficult for him/her to make the connection between the virtual and the real world. Regarding this, such as S. Parsons and S. Cobb (2011) mentioned, an interesting finding is that the more realistic a virtual environment, the more generalization will be achieved, because the scene is more 'believable', and, therefore, skills and understanding are more likely to be transferred from the virtual to the real world.

Moreover, the educator indicated that the street should have more cars rather than two cars, in order to be more realistic. According to this aspect, more cars were added, so that the scene is closer to real life. In this way the child is more likely to transfer the knowledge between virtual and real world easily.

4.2.2 Empirical Evaluation – Children without Autism

Problem Statement

The problem statement of this case study involved several hypotheses, which had to be investigated: The application in the VR CAVE environment:

- is an immersive visualization application
- is close to reality
- can be used for educating children to learn how to cross a street safely
- can be effective in generating, practicing and improving knowledge
- and the devices of it are acceptable for children
- and the devices of it can be understood and used easily for the interaction
- offers a comfortable interaction
- offers an enjoyable way of learning
- offers a pleasant experience

Evaluation Method and Participants

An evaluation was conducted towards the end of the development phase and before the use of the application by the actual target-group. This second empirical evaluation was made with the participation of twelve children (9-10 years old) without autism. The evaluation helped us to measure the application as a learning tool for children in general and to provide feedback for the proper completion of it, before the actual evaluation of the system by children with autism. The evaluation was empirical and was assessed by a pre-test questionnaire, by making observations during the session, and by a post-test questionnaire. Participants were twelve children, five girls and seven boys between 9 and 10 years old, which were selected randomly between sixty children of a primary school. Children came to the lab for a visit, as part of an educational excursion.

Procedure

The procedure for each session was as follows. First of all, the child was asked to wear shoes and glasses which are necessary in order to enter the VR CAVE environment. After that, it was explained to the child how to use the xbox controller in order to interact and navigate within the environment. For a few minutes, we gave the opportunity to the children to play with the xbox controller in order to familiarize themselves with it and learn how to handle it and interact with the environment.

The session for each child consisted of four to six trials which depended on the performance of the child. More specifically, if we considered that a child needed more tries in order to get familiar with the system and understand the meaning of the session, we gave him the opportunity of another try. The steps that each child was expected to execute at each trial in order to complete the session successfully, were the following:

1. Press the button at the crossing box. The child can perform this by pressing the button "A" at xbox controller
2. Look right and left in order to check if cars are moving
3. Wait until cars stop
4. If the cars stop and the pedestrian lights are green then cross the road
5. Cross the road and get to the other side safely

Forms and Questionnaires

A consent form was given to all children's parents prior to the visit and those interested in taking part in the evaluation process returned it, signed by their parents. Participants filled a pre-test questionnaire and a post-test questionnaire. Also, during the session we filled an observation form for each child separately. The pre-test questionnaire contained questions relating to the user's skills with technology, and gaming abilities (e.g. hours per week). It also contained questions relating to the user's level of knowledge about crossing the road safely and how easy the user can get distracted from different tasks. The observation form and the post-test questionnaire focused on specific proposed judgment categories (immersion, realism, adequacy, acceptance, impression, effectiveness).

Evaluation Measures

The following evaluation measures were collected for the qualitative evaluation:

1. Immersion
2. Realism

3. Adequacy of the application
4. Acceptance of the application
5. Users Impression
6. Users Experience
7. Educational tool
8. Effectiveness

Result Analysis and Discussion

Most children reported that they know how to cross the street; one child stated that he/she knows a little, and another one that he/she knows but he/she never before had the chance to cross a road by himself. Almost all children mentioned and showed with their behaviour and feelings that they liked the system. Also, during one of the sessions, when the child heard the sound of the environment, said with admiration and excitement "Oh my god". Only one child said that she liked it a little bit, and that she was scared but she was still smiling. In addition, this child stated that she believes she was not good. Furthermore, almost all children showed samples of excitement, they laughed and smiled during and after the completion of the session and gave us to understand that they enjoyed the whole experience. One child was more reserved, while he mentioned that he liked the application he did not seemed excited about it. Children did not give signs of dissatisfaction or that they felt uncomfortable, only a child said that he/she felt dizzy; however he/she also said that she liked it.

Furthermore, from the post-test questionnaire, we derive that all children characterize their experience with the VR CAVE as a pleasant experience, and the interaction with it as a comfortable interaction (see Table 1). Also, only the 27.27% of children (three) mentioned that they felt dizziness (see Table 2). From that we derive that their impression and experience for the application was positive and encouraging. Also we derive that the children accepted the application and their interaction with it.

Table 1: Users Impression/ Experience/ Acceptance - Pleasant Experience and Comfortable Interaction

	YES	**NO**
Pleasant experience	100%	0%
Comfortable interaction	100%	0%

Table 2: Users Experience/ Acceptance - Dizziness

	YES	**NO**
Dizziness	27.27%	72.72%

In addition, from the post-test questionnaire, regarding the evaluation measures about experience and impression of users, we can add that children mentioned as positive points of their experience the 3d imaging of the environment, the virtual world and objects, and the animations of virtual objects. Specifically children mentioned as positive points the clean environment, the cars, the animation of cars and the fact that cars can stop the hand and the animation of that which represents the click on the crossing button. Moreover, as positive point children indicated the view, the perspective that the system offers, the fact that they can see the cars better, and the fact that character can moves fast. Also a child mentioned the sound at the environment as a positive point of experience, but two other children mentioned it as a negative point of their experience. Here we must mention that the sound used in this experiment is not the same sound that will be used in the experiment of children with autism. (See Diagram 2)

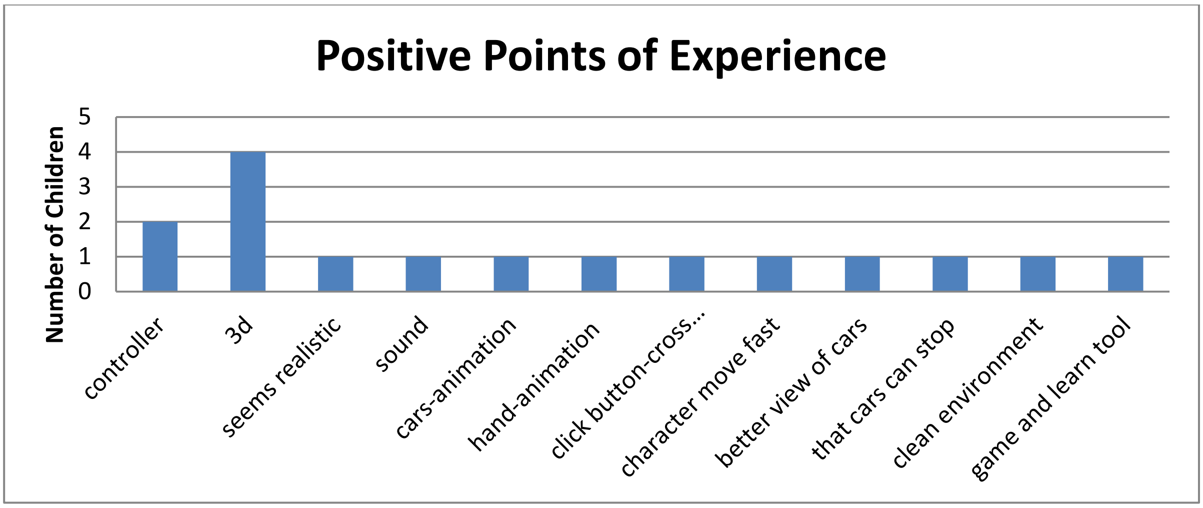


Diagram 2: Positive Points of Experience

They were many children and the available time for the completion of all sessions was limited, so the time that each child spent using the application was also limited. In addition, there was enough fuss during the session; this had an impact on the children. Children had limited time to use and interact with the system so it was difficult for them to understand the meaning of the session or immerse themselves. For us it was difficult to observe accurately all the reactions or behaviours of the children. So, the only sample, that we were able to observe, relating on the immersion of children was that one child said “ououououou” with enthusiasm, when he moved right and left at the crossing. Moreover, we observed an activity that hindered immersion; a child looked outside to us in order to get help about what to do next, instead of focusing on the system and trying to complete the session alone.

From the post-test questionnaire, regarding immersion of children we measured that 63.63% of children answered yes to the question ‘Did you feel any moment immersed that you forgot that you were in a virtual environment?’, and only 36.36% of them answered no (see Diagram 3). From that we can derive that most children felt fully immersed in the system. Furthermore, 90% of the children answered yes to the question that compared the compatibility of their experience in virtual environment with an experience in real world (see Diagram 4). Also a child mentioned as a positive point of the experience that the system seems realistic. Two negative points of the experience that related to the level of realism are: a child mentioned as a negative point of experiment the fake colours and another one the fact that cars stopped abruptly/suddenly. From that we derive that most children found that the system offers high levels of realism and that a few modifications are necessary in order to get closer to reality.

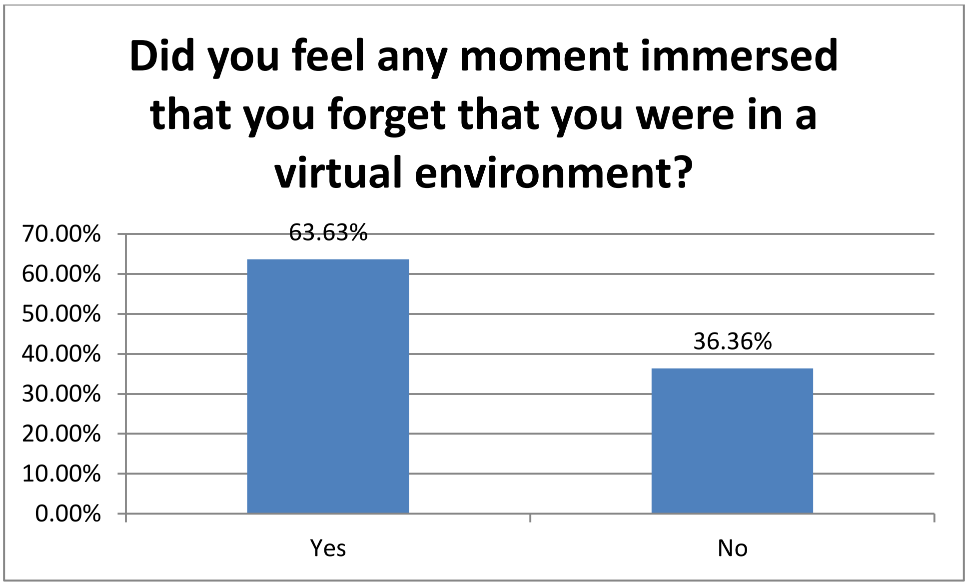


Diagram 3: Immersion - Did you feel any moment immersed that you forget that you were in a virtual environment?

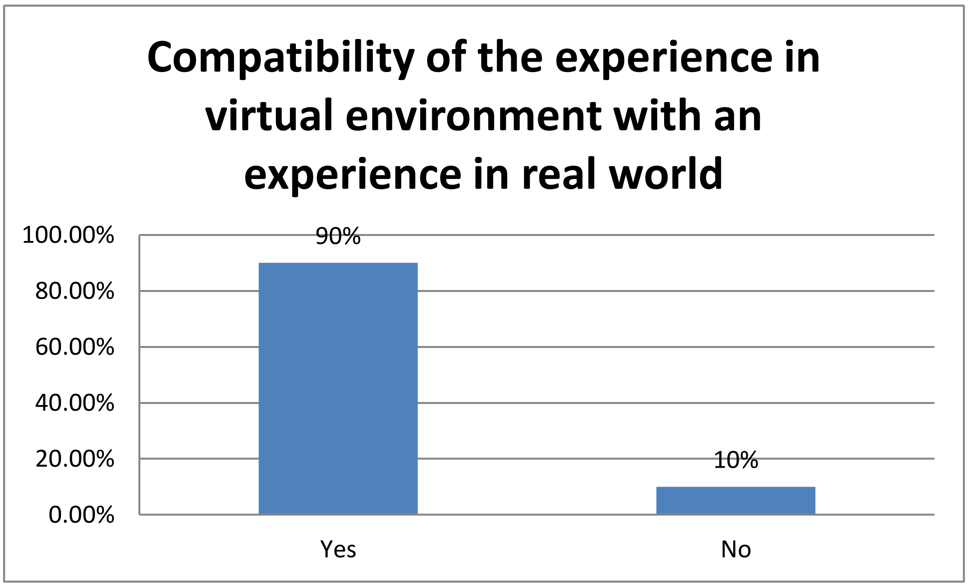


Diagram 4: Realism - compatibility of their experience in virtual environment with an experience in real world

Some other observations were made, relating to difficulties or problems that children had faced. Three of the children tried to walk and cross the road and not by using the xbox controller. After we explained the way to do so they were able to navigate correctly. Two other children faced difficulties at the beginning until they learn how to use the xbox controller (e.g., how to push button A, what keys to use to navigate). One other child, had difficulties at the beginning until she understood the meaning of the session and what to do. This was evident from how the session started. During the first try she crossed before cars stopped and during the second try she did not look at the cars or lights. After the third try she understood the goal of the session and she was able to complete it properly, following all the steps correctly. In addition, another child had the same difficulty to understand the meaning of the session; also the same child had difficulty in handling the xbox controller, she was asking continuously what to do next, she probably misunderstood the purpose of the session, she thought that she was supposed to follow instructions from us instead of acting alone and think of what to do in order to complete the session. Until the third try she did not take initiative. On the third and fourth try she acted alone, she waited until cars stopped but did not wait until lights became green and crossed the street.

From the post-test questionnaire, regarding the adequacy of the application we measured if children found the use of the equipment (hand controller/ glasses/ shoes) restrictive. The 54.54% of children found it restrictive and the 45.45% they did not find it restrictive (see Diagram 5). On the other hand, two of the children mentioned as a positive point of experience the controller and one child that you can just click a button in order to cross the street (see Diagram 6). Because the percentages are close we could say that the equipment may restrict children from their interaction with the system. Also some children liked the use of the controller and the opportunities that it offered.

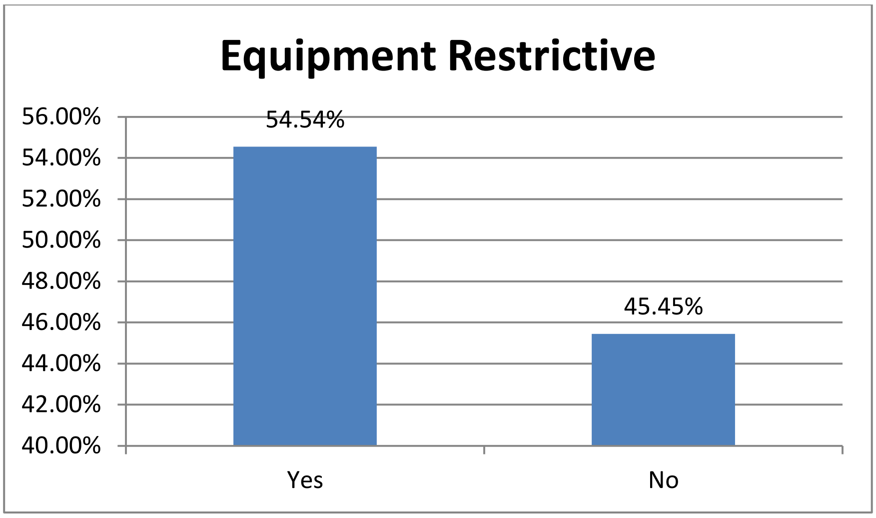


Diagram 5: Adequacy - Equipment Restrictive

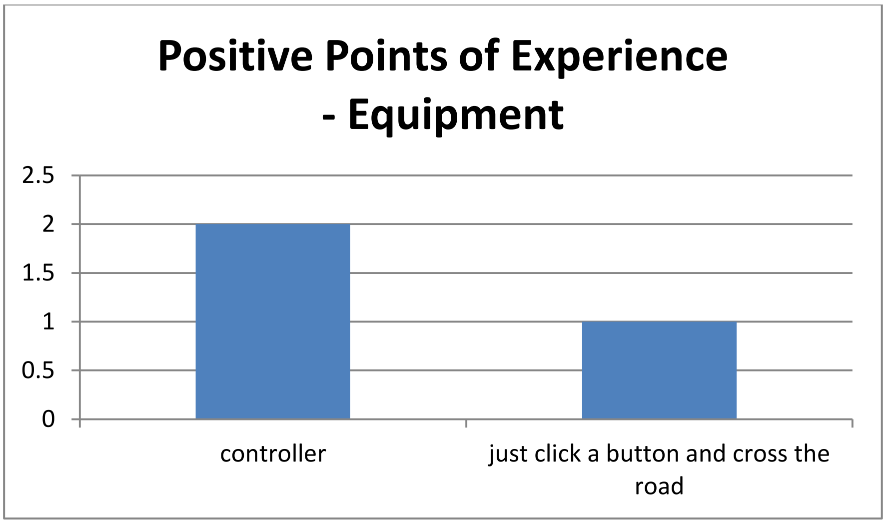


Diagram 6: Adequacy - Positive Points of Experience - Equipment

Next we mention some general observations regarding the progress of children during the session. Three of the children performed all the appropriate steps in order to complete the session successfully, in all their four tries. One child first waited until the cars stopped but did not wait until the lights became green, during the second try and after he waiting for the lights to be green and executed all steps correctly. Another child, at the first three tries executed all steps correctly, but at the fourth and last try he crossed the road before cars stopped and before lights became green. Furthermore, one child in all trials waited until lights became green and then crossed the street but she did not look right and left at cars in order to check if cars had stopped. Something that in real life is dangerous because often at crossings the lights become green but cars are still moving.

Several children, waited until cars stopped but they did not check whether lights become green before crossing the street. Another common behaviour in some children is that they waited one of the two groups of cars to stop and if the other group was far away then they crossed the road; behaviour that people tends to follow in real life (see Diagram 7). For example, a child during the first tried crossed the street when the second group of cars stopped but she did not wait for the first group. In the second and third try she executed all the right steps, but in the fourth try she waited until cars stopped but crossed the road before the light became green. Another child, at the first trial waited until cars stopped and then waited for us to say “go” in order to cross the road. In the second try she waited for cars to stop but crossed the road before lights became green; in the third try she checked right and left for cars but crossed when the second group of cars stopped and first group was far away. Also a child in the first two tries waited for cars to stop but did not wait for lights to become green. The same child in the last two tries checked cars but did not wait for them; he just confirmed that cars were far away and then crossed the road. Moreover, a child in the first two tries looked at cars but did not wait for them in order to cross the road. In the third try he waited for the first group of cars but not the second one, in the fourth try he tried to cross when cars were far away but the educator told him “no”, and then waited for the first but not the second group, he just checked that it was far away. At the fifth and sixth try he waited for cars until stopped but did not wait for the lights to become green. Diagram 7 summarizes those common behaviours between children in the different trials. The total number of trials of all children together is 52. At six of those trials, we observed the common behaviour that children wait for cars to stop but do not check or wait for lights to change to green and then cross; and at eight of those trials children waited only one of the two groups of cars to stop or they did not wait for any of the groups and then cross.

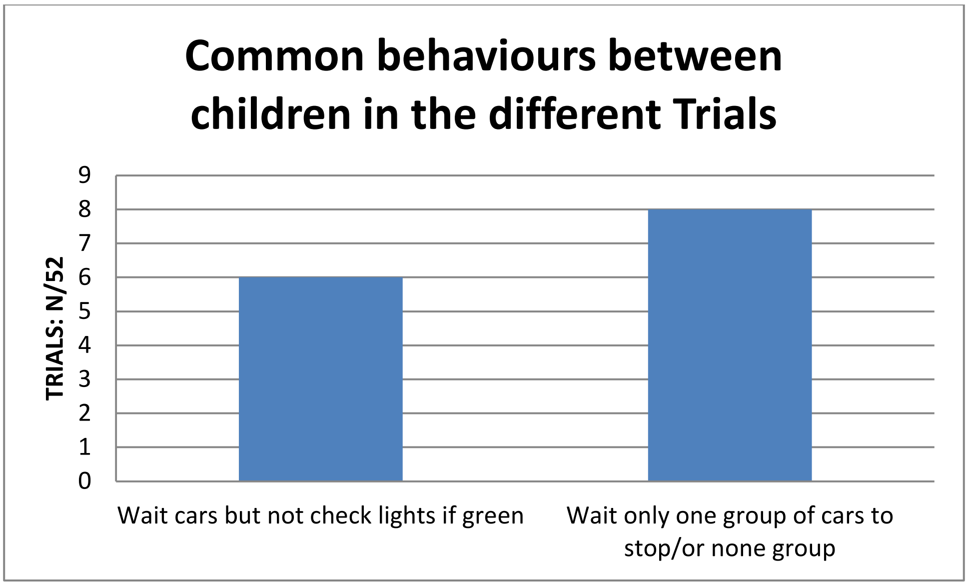


Diagram 7: Common behaviours between children in the different trials. The total number of trials of all children together is 52

Summarizing the above, we also derive that children seem to enhance their performance in the intermediate trials. This can attribute to the fact that during the initial trials, in contrast to the intermediate trials, children try to adapt to the environment and understand the purpose of the session but also how to interact with the system. Furthermore, during last trials children may be tired, or have started to lose their interest because of repeated trials.

From the post-test questionnaire, we derive that all children believe that the VR CAVE environment can be used as an educational tool with positive effects (see Diagram 8). Also a child mentioned as a positive point of experience that the application seems like a game and at the same time though it you can learn. Moreover, 54.54% of children mentioned that the VR CAVE improved their knowledge about crossing, and the other 45.45% believe that it did not improve their knowledge (see Diagram 9). Because the percentages are close we could say that the application may improve their knowledge about crossing. Regarding the evaluation measure of the effectiveness of the application a significant number of children believes that the application effectively improved their knowledge about crossing. Moreover, all children believe that the application can be used as an educational tool with positive effects, and that through it they can learn.

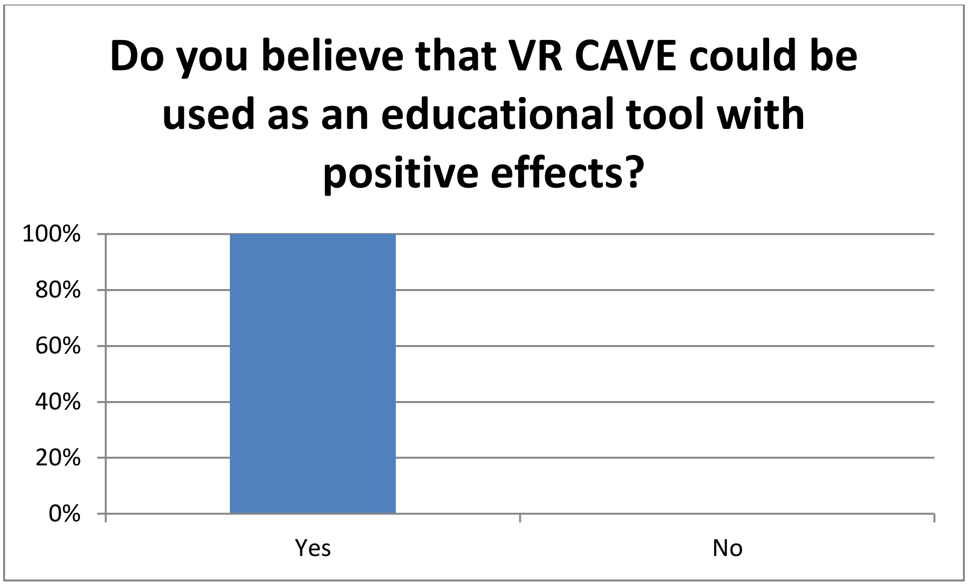


Diagram 8: Educational tool and Effectiveness – Do you believe that VR CAVE could be used as an educational tool with positive effects?

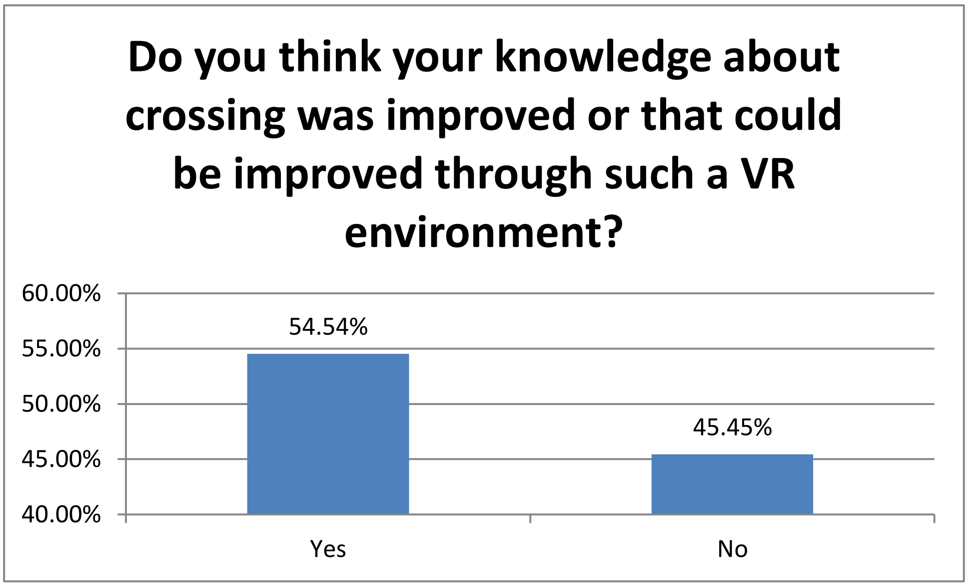


Diagram 9: Educational tool and Effectiveness – Do you think your knowledge about crossing was improved or that could be improved through such a VR environment?

General Results and Discussion

Adequacy and Acceptance of the application

We derive that children accept the system and that the devices are appropriate in order to interact with it. Furthermore, they have the ability and they are able to use the system and its devices. None of the children complained about the glasses or the shoes that they had to wear. Also, children who had difficulties with handling the xbox controller were few and this happened only at the beginning of the session, until they learned how to use it. Children learned how to handle it very quickly, and then they were ready to interact with the system properly in order to complete the session. None of the children faced an important difficulty regarding the devices or the controller to an extent that was impossible to complete the session, or adversely affect their performance.

Furthermore, we derive that the equipment (hand controller/ glasses/ shoes) may restrict children from their interaction with the system; on the other hand some children mentioned as a positive point of their experience the use of the controller and the opportunities that it offers (click to cross the street).

Impression, Experience of users and Acceptance of the application

Moreover, we conclude that the system can be considered as an enjoyable way of learning, even in situations where the training at the real world judge as unsafe way of learning. Children showed samples of excitement, they laughed and smiled during and after the completion of the sessions and gave us to understand that they enjoyed the whole experience. Only one child mentioned that she was scared and that she liked it a little bit. Also, they did not face important issues about the system and did not give signs of dissatisfaction or like they felt uncomfortable, only three children said that they felt dizziness; however they were able to complete the session normally. Furthermore, all children characterized the experience with the VR CAVE as a pleasant experience, and the interaction with it as a comfortable interaction. The impression and experience of the children of the application is positive and encouraging. Also we derive that children accept the application and the interaction with it.

Immersion and Realism

Most children felt immersed in the system, as 63.63% of them answer yes to the question 'Did you felt at a moment engrossed that you forget that you were in a virtual environment?' A sample we were able to observe, relating on the immersion of children was that one child said "ououououou" with enthusiasm, when he move right and left at the crossing. In addition, 90% of children answered yes to the question that counts the compatibility of their experience in virtual environment with an experience in real world. From that we derive that system offers high levels of realism and that few modifications could be made in order to get closer to reality (realistic colours and cars stop smoother).

Educational tool and Effectiveness

All children believe that the VR CAVE environment can be used as an educational tool with positive effects. Indeed, a child mentioned as a positive point of experience that the application seems like a game and at the same time though it you can learn. Regarding the effectiveness of the application, we derive that a significant number of children believed that the application effectively improved their knowledge about crossing.

This empirical evaluation help us to understand important features which must identified a session in order the training be correct, complete and effective. These features must be taken into account so that the training with children with Autism be done properly and be appropriate for the transfer of knowledge. First of all, especially for the education of children with Autism, time should not restrict us. Should devote as much time as needed to each child, to explain what should do at every part of the session and to explain every mistake that has made in every part, so that to not repeat it again in the next try. Children should have the possibility to perform as many tries as needed until they are able to successfully complete the session. In this way, the knowledge will be 'digested' better and the learned skills could lead to new abilities.

Moreover, there needs to be silence during the sessions, in these way children will be concentrated in learning and they will not be distracted by anything else. In addition, this will help children to focus on the system and the visualization. In this way children will have more chances to immerse themselves in the system and acquire new knowledge.

Livatino Salvatore and Koeffel Christina (2008) in "Simple Guidelines for Testing VR Applications" mentioned that distractions such as loud noises might disturb the sense of presence.

Viewing comfort

A category that derives from the qualitative analysis that was not included in the initial measures but was extracted from the data we collected from children's answers is the viewing comfort. A child indicated as positive point of experience with the VR CAVE environment the view point of the system; the perspective that the system offers, the fact that they can see the cars better.

4.2.3 Summative Evaluation – Children with Autism

Problem Statement

The problem statement of this case study involved several hypotheses, which had to be investigated: The application in the VR CAVE environment:

- is an immersive visualization application
- can be used for educating children with autism to learn how to cross a street safely
- can effectively involve to the enhancement and improvement of their social skills and behaviours (specially for crossing a street)
- can be effective in generating, practicing and improving knowledge (crossing a street)
- help children to the real world
- help children to apply the knowledge to the real world
- is beneficial for children with autism
- and the devices (glasses, shoes) of it are acceptable from children
- and the device (hand controller) of it can be understood and used easily for the interaction by educator
- offers a comfortable interaction
- offers an enjoyable way of learning
- offers a pleasant experience

- is adequacy for the purpose of training children with autism

Evaluation Method and Participants

As an interactive system, the user study is appropriate, to assess whether the project was successful. The evaluation we hoped to perform, as a summative evaluation, was an empirical evaluation with children with autism. We hoped that a number of children with ASDs would take a session using the application in a VR CAVE environment for the training of specific social skills. The engagement and the use of the application by children during the session would be measured which would provide an insight of the effectiveness of the application. All the procedures required for the organization and realization of this summative evaluation, were performed. Unfortunately, none of the parents of children with autism responded positively or allowed to the proposal for the participation of their children as part to the process of the evaluation of the application.

The participants of the summative evaluation would be:

- A child with autism, who would be the main user of the application
- The educator which would be in the VR CAVE environment next to the child and would handle the session. Educator should give instructions to the child and try with the help of the system to transfer knowledge about how to cross the road safely
- The parents of the child who would accompany their child and would be able to watch the whole process of session. The present of parents would help the child to feel more comfortable and adjust to the environment of the lab easily.

The summative evaluation would be empirical and would be assessed by making observations during the session to the child with autism, and by two post-test questionnaires: one that regards the educator and one for parents of the child.

Procedure

The procedure for each session would be as follows:

- It was explained to the educator about the role that he/she would play during the session

- Give instructions to the educator about the procedure that would be followed for the session; the parts that the session would be split into and what is the goal of each part.
- It was explained to the educator how to use the xbox controller in order to interact and navigate within the environment, and how to send signals to the application e.g. who to stop cars. The basic interactions are:
    - Navigation
    - Click ‘A’ button when child push the button on crossing
    - Stop cars (with two buttons)
- The child was asked to wear shoes and glasses which are necessary in order to enter the VR CAVE environment. The child would have as much time as needed in order to feel comfortable with the system and the equipment. In this way, we give the opportunity to the children to familiarize themselves with the system and accept the equipment.

The child would have as much time and tries as needed at every single part of the session in order to understand the meaning of each part and complete the parts of the session successfully. The educator will be able to judge whether the child needs more trials or whether is able to continue at the next part of the session. In this way, the knowledge will be ‘digested’ better.

The training will be split in various parts so that the child builds step by step the knowledge which is necessary in order to cope with the next part of the treatment. In this way the new knowledge will be “digested” better.

The parts of the training will be executed as follows:

Part A

During this part of the training the child should learn to recognize, track, and avoid the moving cars within the virtual street scene

Part B

The child should learn to recognize and find the crossing button, walk to it, stop, and press it

- First it will be explained and shown to the child where the crossing button is in the scene
- Then the child should find/identify the crossing button (Where is the crossing button?)
- Then it will be explained to the child that he/she should press the button

Part C

The child should be learn to recognize the lights and learn to interpret them (red light means stop and green walk)

- Will be explained to the child where the lights are
- The child should identify the lights
- Will be explained to the child the meaning of lights
    - When lights are red you must wait at the crossing
    - When lights are green and cars have stopped you can cross the road

Part D

The child should be learn to recognize the crossing and walk to it if he can – according to the lights and cars.

- Will be explained to the child where the crossing is
- The child should identify the crossing
- Will be explained to the child that first he/she should check if lights are green
- Will be explained to the child that after that he/she should turn his head right and left to check if cars have stopped
- Will be explained to the child that if the above two statements are true then he will be able to cross the road

Part E

The final part will be the most difficult; the child has to cross the street alone without any help. The session will be executed from the beginning and the child should cross the street alone.

As we mentioned above the educator would be one of the users of the application in the VR CAVE environment during the session. The educator would be next to the child during the session and guiding the child, while giving instructions about the activities that child should perform at each part of the session. Every part of the session would be explained to the child with the proper way in order to understand the meaning and the reason why to perform each activity. It should be understandable to the child the reason that every single action could lead to the completion of the action "cross the street safely". Moreover, the educator would explain to the child the errors that he/she made in order to not perform them again and the right way of doing things. Also, the educator would reward children when perform a correct action, activity or completed each part of the session or the whole session. In addition, the educator would handle the xbox controller, in order to send signals to the application e.g. when to stop cars.

Forms and Questionnaires

Informational letters were sent to two different organizations ("Cyprus Autistic Association", and "Orizontas") related with children with autism. With these letters we informed organizations of the purpose of the research and we asked for the assistance and cooperation of the organization in the completion of the research. Both organizations were positive in our proposal. After that informational letters and consent forms were given to parents with children with autism. Unfortunately, none of the parents responded to our proposal. After that, the evaluation of the system with the participation of children with autism was impossible.

The evaluation of the system planned to measure with post-test questionnaires, with open type questions that educator and parents would fill in and with observation forms relating to the children's interaction and engagement with the system. During the session, we filled an observation form for each child separately. The observation form and the post-test questionnaire related on user’s background, the autism level, and on specific proposed judgment categories (immersion, adequacy, acceptance, impression, effectiveness, educational tool).

Evaluation Measures

The following evaluation measures should be collected and calculated for the quantitative and qualitative evaluation:

For the quantitative evaluation:

1. Time to complete the session
2. Succeed to complete the session
3. Number of trials at each part of the session
4. Number of errors at each part of the session
5. Kind of errors at each part of the session
6. Succeed to complete each part of the session

For the qualitative evaluation:

1. Immersion
2. Adequacy of the application
3. Acceptance of the application
4. Users Impression
5. Users Experience
6. Educational tool
7. Effectiveness

Data collection related on evaluation measures

For the evaluation of the application we had to consider the degree of involvement and use of the application by children during the sessions. Also we would have to examine whether children were able to accept and use the equipment (glasses, shoes) of the application in the VR CAVE environment. Furthermore we would have to examine whether children interact in a meaningful way with the environment and whether the application effectively enhanced and improved social skills by children. In addition, it should be taken into account whether children would be able to successfully complete the sessions and whether they would succeeded in transferring knowledge from the virtual to the real world.

The set of measurements would be multiple observations of each child performing every part of the session over many trials. Behaviours, feelings, difficulties, problems, actions or activities of the children should be recorded and analysed. Furthermore educator and parents would complete questionnaires with open questions. In this way we would collect additional information that could help us extract reliable results. The educator would provide information about the application in the VR CAVE environment and the interaction with it because the educator would be one of the users during the session. Also, as an expert, and as a person who daily comes into contact with children with autism he would be able to provide information that we have not noticed or thought of. He would mention things that he observed during each session, like behaviours or activities of the child that would be worth noting. In addition, parents knows their children well, so are the most appropriate people to mention things that they would observe of their child and they considered as important. They would mention any change of behaviours or activities of their child during the session, compared to other days or sessions.

We would like to consider the evaluation measures with some parameters in our evaluation form and questionnaires. Specifically, the evaluation measures taken into account to the form and post-test questionnaires are the following:

Observation Form

1. Immersion
    a. Samples of focus / attention to system
    b. Samples show that feel like holds the system control or immersed himself
2. Adequacy the application
    a. Difficulties, Problems
3. Acceptance of the application
    a. Accept of system, equipment (glasses), shoes
    b. Comfortable/ uncomfortable
    c. Difficulties, Problems

4. Impression of users and Experience of users
    a. Positive fillings: laugh, smile, enjoy, excitement, satisfaction, comfortable
    b. Negative fillings: dissatisfaction, rankled, resents, dislike, uncomfortable
    c. Facial Expressions
    d. Imagination
5. Educational tool and Effectiveness
    a. Communication with educator or other people (verbal or with his body)
    b. Samples of realize/perceive of his body
    c. Imagination
    d. Behaviours or Stereotypical Behaviours
    e. Actions, Activities
    f. Time to complete the session
    g. Succeed to complete the session?
    h. Number of trials at each part of the session
    i. Number of errors at each part of the session
    j. Kind of errors at each part of the session
    k. Succeed to complete each part of the session?
    l. Appropriate responses: carry out instructions, follow instructions, head shake, eye contact, pointing, other (e.g. listening)
    m. Inappropriate responses: no responses, lack of eye contact, lack of focus, no response to instructions, topic change
    n. Recognize, identify, track (watch, follow), avoid moving cars?
    o. Recognize, find, identify, and press the crossing button?
    p. Wait after press it?
    q. Recognize, find, and identify the lights?
    r. Understand the meaning of the lights?
    s. Wait when light is red?
    t. Wait when cars moving?
    u. Focus/see on cars when those have stopped?
    v. Recognize, find, and identify the crossing?

w. Focus/see on green lights? Check if lights are green?
x. Focus/see on stopped/ stationary cars?
y. Turn head – right, left (check if cars are stopped?)
z. Walk to crossing if he can? According to lights and cars? – Cross the road?

Questionnaire for educator

1. Adequacy of the application
    a. Any problem or difficulties with the control of the lesson/how to handle the training? (e.g., How to stop cars?)
    b. Is there something that needs to be changed, modified, added or removed?
2. Acceptance of the application
    a. How easy it was to learn to handle and use the xbox controller?
    b. Any problem or difficulty with the way of navigation?
    c. Any problem or difficulties with the control of the lesson/how to handle the training? (e.g., How to stop cars?)
3. Educational tool and Effectiveness
    a. Do you think it could help children with autism to learn how to cross the road safely?
    b. Do you think it could help children with autism with any other way?
    c. Did you notice any changed at behaviours or activities of children during the session, compared to other days or sessions?

Questionnaire for parents

1. Educational tool and Effectiveness
    a. Do you think it could help your child or other children with autism to learn how to cross the road safely?
    b. Do you think it could help your child or other children with autism with any other way?
    c. Did you notice any changed at behaviours or activities of your child during the session, compared to other days or sessions?

4.2.4 Summative Evaluation with Educators of children with Autism

Problem Statement

The problem statement of this case study involved several hypotheses, which had to be investigated: The application in the VR CAVE environment:

- is an immersive visualization application
- can be used for educating children with autism to learn how to cross a street safely
- effectively involved to the enhancement and improvement of their social skills and behaviours (specially for crossing a street)
- can be effective in generating, practicing and improving knowledge (crossing a street)
- help children in real world
- help children to apply the knowledge in real world
- is beneficial for children with autism
- and the devices (glasses, shoes) of it are acceptable from children
- and the device (hand controller) of it can be understood and used easily for the interaction by educator
- offers a comfortable interaction
- offers an enjoyable way of learning
- offers a pleasant experience
- is adequacy for the purpose of training children with autism
- is a place that children can focus and concentrate for the purpose of learning
- compared to existing methods of treatment about crossing a street safely, could offer something more, and lead to the desired effects
- can be used in combination with existing methods of treatment about crossing a street safely

Evaluation Method and Participants

As an interactive system, the user study is appropriate, to assess whether the project was successful. The evaluation we hoped to perform, with children with autism, was not carried out. After this suffix, we decided to proceed to a second plan. For the summative evaluation, we conducted another empirical evaluation with the participation of educators, who specialize in education of children with autism. As experts in the education of children with autism they will be able to evaluate the system as a learning tool for children with autism. Furthermore, they will be able to evaluate whether it can be used in order to enhance and improve the social skills and behaviours of children, especially in education about how to cross a road safely.

The participants of the summative evaluation were two educators who specialize in the education of children with autism, and they currently work for the Cyprus Autistic Association. The first educator was a woman and specialized in logo therapy (logo therapist); the second educator was a man and specialized in music therapy (music therapist).

The summative evaluation was empirical and assessed by post-test questionnaires, which educators completed after the completion of their experience in the VR CAVE environment.

Procedure

The procedure for each session that was followed was the same as the procedure to be adopted in the case that the child with autism will be present. The educator was in the VR CAVE environment, handles the session and gives instructions to a person who took the place of the child with autism.

The procedure for each session was as follows:

- It was explained to the educator about the role that will be played during the session
- Give instructions to the educator about the procedure that will be followed for the session; the parts that the session would be split and what is the goal of each part.
- It was explained to the educator how to use the xbox controller in order to interact and navigate within the environment, and how to send signals to the application e.g. who to stop cars. The basic interactions are:
    - Navigation
    - Click ‘A’ button when child push the button on crossing
    - Stop cars (with two buttons)

- The educator was asked to wear shoes and glasses which are necessary in order to enter the VR CAVE environment.
- The educator entered the VR CAVE environment and interacted with the system. Understood the features, the possibilities and opportunities that the application offers.
- Executed the procedure of the session (the different parts) like in the case that the child with autism will be present.

After the completion of the experiment within the VR CAVE environment, the educator completed a post-test questionnaire with open questions.

Forms and Questionnaires

An informational letter was sent to “Cyprus Autistic Association”. With this letter we informed organization for the purpose of the research and we asked for the assistance and cooperation of the organization to the completion of the research. The organization was positive in our proposal. After that informational letters and consent forms were given to educators of children with autism.

Furthermore, the educators, on the day of conducting the evaluation of the system, took instructions about the procedure that will be followed for the session; the parts that the session will be split and what is the goal of each part. Also, educators took instructions about how to handle the xbox controller in order to interact and navigate within the environment, and how to send signals to the application, during the session.

The evaluation of the system, measured with post-test questionnaires, with open type of questions that educators filled. The post-test questionnaires related on user’s background, and on specific proposed judgment categories (immersion, adequacy, acceptance, impression, effectiveness, educational tool).

Evaluation Measures

The following evaluation measures collected for the qualitative evaluation:

1. Immersion
2. Adequacy of the application
3. Acceptance of the application

4. Users Impression
5. Users Experience
6. Educational tool
7. Effectiveness

Result Analysis and Discussion

Immersion

Educators agree that it depends on the child how well he/she will focus and concentrate on the system and session. Also, mentioned that it may take several sessions in order to achieve this.

Adequacy and Acceptance of the application

Both of the educators mentioned that it was very easy for them to understand and learn how to handle the xbox - hand controller and its functionalities. For example how to navigate in the environment and send the appropriate signals during the training. Also, none of the educators faced any problem or difficulty with navigation in the environment or with controlling, handle the training (e.g., how to stop cars).

Moreover, to a question relating on something that needs to be changed, modified, added or removed from the application, one of the educators mentioned that the colours of the signs (green, red lights) would be better to be bolder and brighter in order to be easily perceived by children with autism.

In addition, one of the educators believed that children will accept and feel comfortable with the system and devices and they will be able to interact with it, and use the devices. The other educator mentioned that this depends on the child.

Both educators believe that a difficulty or problem that children might face is that they must stand in a specific space in the VR CAVE environment without moving around. They suggest that some equipment that would restrict and guide the movement of children in the space could be added. Also, one of the educators mentioned as another difficulty for children the fact that they must wear glasses.

Impression and Experience of users

The impression and experience of the users was positive and encouraging. We heard positive comments; educators mentioned that the application in the VR CAVE environment was very interesting and that good work was carried out.

Educational tool and Effectiveness

Educators believe that the application in the VR CAVE environment could help children with autism to learn how to cross the road safely. One of them mentioned that it could help children with autism but not children with low functionality. In addition, one of the educators believed that it could help children in other ways; mentioned that there could be many things incorporated in the lesson.

Both educators agree that children could perform the appropriate activities in each part of the session and they will be able to complete the parts of the session successfully. Furthermore, educators also agree that this depends on each child's ability to focus and concentrate on the system and session. They also, mentioned that it might take several sessions in order to achieve this.

Moreover, one of the educators believes that children could follow the instructions of the educator during the session, while the other educator believes that it depends on the child.

Educators mentioned as advantages of this way of training children with autism, especially for this purpose (crossing a street), the feature of the application that the image is 3D and realistic. Also, mentioned that the application in the VR CAVE environment for this purpose is really interesting.

Both educators referred to the social stories as the existing method that they would use for educating children with autism about crossing the road safely. Also, both of them agree that the approach using the VR CAVE could offer something more and new, especially when combined with social stories. One of the educators mentioned also that the VR CAVE would be better when comparing the two approaches and would lead to the desired effects. In addition both educators also agree that they would use the two approaches in combination.

General Results and Discussion

Summarizing the above, the evaluation with educators of children with autism was encouraging. We heard positive comments and educators mentioned that the application in the VR CAVE environment is very interesting and that good work was carried out.

The device (hand controller) of the application can be learned and used easily for the interaction by the educator. Both of the educators mentioned that it was very easy for them to understand and learn how to handle the xbox - hand controller and its functionalities. Also, they did not face any problem or difficulty with the way of navigation or with controlling, handle the training.

Every child with autism is unique and differs from the other children. The skills and abilities of each child differ. For this reason, the possibility the child focus and concentrate on the system and session, depends on each child separately. Also, it might take several sessions in order to achieve this.

Furthermore, regarding the adequacy and acceptance of the application by children it depends on the child if he/she will accept and feel comfortable with the system and devices and if he/she will be able to interact with it, and use the devices. A common issue for all children is the fact that they should wear glasses.

In order for the application to be adequate for the purpose of training children with autism, some modifications can be made. First some equipment could be added that would restrict and guide the movement of children in the space; because children with autism cannot easily stand in a specific place without moving around. Also another modification that could be made are the colours of the signs (green, red lights); it would be better to be bolder and brighter in order to be easily perceived by children with autism.

We derive that the application in the VR CAVE environment could help children with autism to learn how to cross the road safely; but, it is not suggested for children with low functionality. In addition, it could help children with autism in other ways; there could be many things incorporated in the lesson. Children could perform the appropriate activities in each part of the session and they will be able to complete the parts of the session successfully. So, we derive that the application in the VR CAVE environment can be used as an educational tool for some children with autism, and effectively aid in the enhancement of social skills and behaviours of children relating with crossing a road safely. Also, it can be used to generate and improve new knowledge (cross the road) with practice, and in this way help children apply the knowledge to the real world.

Advantages of this way of training children with autism, especially for this purpose (crossing a street), is the feature of the application that the image is 3D and realistic. The fact that it is close to realism could help children to transfer the knowledge from virtual to the real world more easily. Also, educators mentioned that the application in the VR CAVE environment for this purpose is really interesting.

The approach with VR CAVE can be used in combination with social stories (existing method of treatment) for training children with autism about crossing a street safely. Also the VR CAVE approach could offer something more and new, especially when combined with social stories. One of the educators mentioned that the VR CAVE would be better when comparing the two approaches and would lead to the desired effects.

5. Discussion

5.1 General Results

In summary, because the evaluation of the system was not conduced with children with autism, the overall view we derived, is not complete. On the other hand the finds are valid because the summative evaluation was carried out with the participation of educators of children with autism. The results are valid because educators know children with autism well, theirs peculiarities, behaviours, and how they react on educational procedures. Furthermore educators know how the training should be structured in order to be appropriate and adequate for children with autism. Also, educators know how the training should be conducted in order for new knowledge to be created and for the child to transfer the knowledge in his/her life.

For all these reasons we are able to say that the results we derived at are valid and common to the results that we would be derive from the evaluation of the system with the participation of children with autism. Also, the results and finds we derive are close to the results that would be export from the evaluation with children with autism. However we could not say that these results are equal to the finds that we would have in the case of an evaluation of the system with children with autism.

First of all, the hand controller (xbox) and its functionalities it can be learned and used easily for the interaction by educator and for handling the session.

Every child with autism is unique and differs from the other children. The skills and abilities of each child differ. For this reason, the possibility the child focus and concentrate on the system and session, depends on each child separately. Also, it might take several sessions in order to achieve this. For that we derive that for an effective session the time should not restrict us; should be offer as many sessions and trials as needed to each child separately in order to achieve to focus on the system, and session and to be able to generate a new knowledge. This is not an obstacle to this way of training; the application in VR CAVE environment gives the opportunity to executed as many trials and sessions as needed.

The same find was extracted earlier from the evaluation of children without autism. We derive that time should not restrict us in order for the training with children with autism to be correct, complete and effective and appropriate for the transfer of knowledge. In this way, the knowledge will be 'digested' better and the learned skills could lead to new abilities.

Moreover, from the expert evaluation and from the evaluation of children without autism we derive that during the session should prevail quiet, in this way children will be concentrated in education and they will not distracted by anything else. In addition, this will help children to focus on the system and to the visualization. In this way child will have more chances to immersed himself to the system and acquire new knowledge. Livatino Salvatore and Koeffel Christina (2008) in "Simple Guidelines for Testing VR Applications" mentioned that distractions such as loud noises might disturb the sense of presence.

Furthermore, regarding the adequacy and acceptance of the application by children with autism it depends on the child if he/she will accept and feel comfortable with the system and devices and if he/she will be able to interact with it, and use the devices. A common issue for all children with autism is the fact that they should wear glasses.

In addition, we derive that the application in the VR CAVE environment could help children with autism to learn how to cross the road safely; but, is not suggested for children with low functionality. In addition, it could help children with autism and in other ways; there could be many things incorporated in the lesson. Children could perform the appropriate activities in each part of the session and they will be able to complete the parts of the session successfully. So, we derive that the application in the VR CAVE environment it can be used as an educational tool for some children with autism, and effectively involved to the enhancement of social skills and behaviours of children related with crossing a road safely. Also, it can be used for generate and improved a new knowledge (cross the road) within practice, and in this way help children to apply the knowledge to the real world.

Also we find that advantages of training children with autism with this application, for this purpose (crossing a street), is the feature of the application that the image is 3D and realistic. The fact that is close to realism it could help children to transfer the knowledge from virtual to the real world more easily. As S. Parsons and S. Cobb (2011) mentioned the more realistic a virtual environment, the more generalization will be achieved, because the scene is more 'believable', and, therefore, skills and understanding are more likely to be transferred from the virtual to the real world.

The approach with VR CAVE can be used in combination with social stories (existing method of treatment) for training children with autism about crossing a street safely. Also VR CAVE approach could offer something more and new, especially in combined with social stories. One of the educators mentioned that VR CAVE would be better between the two approaches and would lead to the desired effects. We conclude that application in VR CAVE environment can extend the existing teaching method (social stories) for the training of children with autism, for enhance social skills and behaviours related with crossing a road safely.

A general observation which we derive is that the application cannot be used with the same way from all children with autism. Every child is unique and differs from the other children. Some children may accept and use the system and devices easily while some others may cannot use them at all. Also some children could generate and practice a new knowledge; learn how to cross the road safely while some others cannot achieve this. The important fact that is worth noting is the fact that at least some children could use it and benefit from that. The possibility that a number of children with autism could use the application and enhance and improve their social skills and behaviours, generate a new knowledge, learn how to cross the street safely and transfer the knowledge to their real life.

Some other important findings derive from the evaluation of the application with children without autism. The experience with the VR CAVE is a pleasant experience, and the interaction is a comfortable interaction. The impression and experience of children for the application is positive and encouraging.

Furthermore from the evaluation of the system with children without autism we derive the find that system offers high levels of immersion and realism and that few modifications could be made in order to get closer to reality (realistic colours and cars stop smoother).

In addition, we derive that the VR CAVE environment can be used as an educational tool with positive effects. Also it seems like a game and at the same time though it you can learn.

Moreover, the application effectively involved to the improvement of their knowledge about crossing.

5.2 Future Work

In order for the application to be adequate for the purpose of training children with autism, some modifications can be made, as a future work. Because children with autism cannot easily stand in a specific place without moving around, some equipment could be added within VR CAVE environment that would restrict and guide the movement of children in the space. Also another modification that should be made is the colours of the signs (green, red pedestrian lights); it would be better to be bolder and brighter in order to be easily perceived by children with autism.

Moreover another future improvement that should be made is modifying the colours on virtual objects in order for the scene to be more realistic. In addition another modification that could be made is how the virtual cars stop. The cars now stop abruptly; in order for the whole experience offers high levels of realism cars should stop smoother.

In addition, as future work, we would like to carry out the evaluation of the application with children with autism, in order to extract more accurate results and have an overall view about the use of the application in the training of children with autism. However the main reason is to see whether children could benefit from that. Whether the application could help them in their real life and whether they could see any improvement to their social skills or behaviours.

Furthermore, further work could be to expand the application with scenarios in other unsafe situations. For example, the training of safety rules in fire cases.

Conclusion

Several studies focus on the use of Virtual Reality for social skills training for people with autism. The results are promising and encouraging. In addition, it has been demonstrated that Virtual Reality technologies can be used effectively by some people with autism, and that it has helped or could help them in the real world; while at the same time is has proven to be an enjoyable way of learning.

The goal of this research was to design and develop an immersive visualization application in a VR CAVE environment for educating children with autism. The main goal of the project was to help children with autism learn and enhance their social skills and behaviours. Specifically, we investigated whether a VR CAVE environment can be used by children with mild autism, if it can help them in the real world and whether children can benefit from it and apply the knowledge in their real life. The training was focused in situations of real life which are difficult or impossible to explain to children with the known methods of treatment. We developed a scenario where the child wonders off in the city and losses his/hers parents ("Lost in city"). The goal is children to be prepared to calmly figure out what to do and learn how to cross the street safely.

Unfortunately, the summative evaluation we hoped to perform with children with autism, was not carried out. To overcome this obstacle, as a summative evaluation, we conducted an empirical evaluation with the participation of educators, who specialize in education of children with autism. The results we derived are valid and close to the results that we would derive from the evaluation of the system with the participation of children with autism. However we could not say that these results are equal to the finds that we could have in the case of an evaluation of the system with children with autism.

Also another empirical evaluation was conducted before the actual evaluation of the system, with the participation of twelve children without autism. This evaluation helped us to evaluate the application as a learning tool for children, and to understand important features which must be identified during a session in order for the training to be correct, complete and effective. These features should be taken into account in the training of children with autism.

The main results we derived from both evaluations, were that the application in the VR CAVE environment can be used as an educational tool for some children with autism, and effectively involved to the enhancement of social skills and behaviours of children related with crossing a road safely. Also, it can be used to generate and improve new knowledge (cross the road) within practice, and in this way help children to apply the knowledge to the real world.

Another main result is that the application in the VR CAVE environment can extend the existing teaching method (social stories) for the training of children with autism, to enhance social skills and behaviours relating to crossing a road safely. The application does not replace the existing educational methods and practices; neither operates or supports an independent training. If anything, it comes to extend the existing educational methods, as an additional option.

Also, the application is close to realism which could help children to transfer the knowledge from virtual to the real world more easily. As S. Parsons and S. Cobb (2011) mentioned the more realistic a virtual environment is, the more generalization can be achieved, because the scene is more ‘believable’, and, therefore, skills and understanding are more likely to be transferred from the virtual to the real world.

A general observation which we derive is that the application cannot be used in the same way by all children with autism. Every child is unique and differs from other children. Some children may accept and use the system and devices easily while some others may not be able to use them at all. Also some children could generate and practice new knowledge; learn how to cross the road safely while some others cannot achieve this. The important fact that is worth noting is the fact that at least some children can use it and benefit from that. The possibility that a number of children with autism could use the application and achieve the improvement of their social skills and behaviours, generate a new knowledge, learn how to cross the street safely and transfer the knowledge to their real life.

Furthermore, the application in the VR CAVE environment gives the possibility for each child separately to have as many trials and sessions as needed in order to achieve in generating new knowledge. With more practice the easier it improves knowledge. The child could have as many trials as the educator deems necessary in order to understand the meaning of the training; in this way the knowledge will be 'digested' better and the learned skills could lead to new abilities.

In addition, an important find is that the experience with the VR CAVE is a pleasant experience, and offers comfortable interaction. Also, the system offers high levels of immersion and realism and with few modifications it can get closer to reality (realistic colours and cars stop smoother). Moreover, it can be used as an educational tool with positive effects, and offers an enjoyable way of learning.

In conclusion, the results are promising and encouraging. Hopefully, one day we will be able to carry out an evaluation with children with autism. This will give us the opportunity to extract more accurate results and have an overall view about the use of the application in the training of children with autism. The main reason is to see whether children could benefit from that. Whether the application could help them in their real life and whether this could lead to any improvement in their social skills or behaviours.

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APPENDIX

1.1 Informational Letter - Organization

Immersive and Creative Technologies Lab
Cyprus University of Technology
Basement Floor (-1),
Micrologic Building,
31 Le Corbusier Street,
3075 Limassol,
Cyprus

Αξιότιμε/η κύριε/α,

Είμαι μεταπτυχιακή φοιτήτρια του προγράμματος Μάστερ στα Διαδραστικά Πολυμέσα του Τεχνολογικού Πανεπιστημίου Κύπρου. Για την ολοκλήρωση του μεταπτυχιακού προγράμματος που παρακολουθώ καλούμαι να εκπονήσω Μεταπτυχιακή Διατριβή. Στα πλαίσια της μεταπτυχιακής διατριβής μου αναπτύσσω μια διαδραστική immersive εφαρμογή σε VR CAVE περιβάλλον με στόχο την εκπαίδευση και την βελτίωση των κοινωνικών δεξιοτήτων των παιδιών με αυτισμό. Παράλληλα στόχος της μεταπτυχιακής διατριβής είναι να διερευνηθεί κατά πόσο το VR CAVE περιβάλλον μπορεί να χρησιμοποιηθεί αποτελεσματικά στην εκπαίδευση των παιδιών με αυτισμό. Το VR CAVE περιβάλλον βρίσκεται στο Immersive and Creative Technologies Lab (ICT Lab) (http://www.theictlab.org/)του Τεχνολογικού Πανεπιστημίου Κύπρου. Περισσότερες πληροφορίες για το VR CAVE μπορείτε να βρείτε και στη σελίδα http://www.vrcave.com.cy.

Με την παρούσα επιστολή θα ήθελα να εκφράσω την επιθυμία μου για συνεργασία του εργαστηρίου μας με τον σύνδεσμό σας (Σύνδεσμος για άτομα με αυτισμό Κύπρου) στην ολοκλήρωση της μεταπτυχιακής αυτής εργασίας. Η συνεργασία και η βοήθεια που μπορεί να μας προσφέρει ο σύνδεσμός σας είναι πολύτιμη για εμάς καθώς χρειαζόμαστε τη βοήθεια ενός μικρού αριθμού παιδιών (2-3 παιδιά) και των γονέων τους που είναι μέλη του συνδέσμου σας για την διεξαγωγή της αξιολόγησης της εφαρμογής που αναπτύχθηκε. Με την συμμετοχή των παιδιών στην αξιολόγηση της εφαρμογής θα μπορέσουμε να εξάγουμε συμπεράσματα όπως κατά πόσο αυτή η εφαρμογή μπορεί να χρησιμοποιηθεί στην εκπαίδευση των παιδιών, κατά πόσο μπορεί να εμπλακεί αποτελεσματικά στην ανάπτυξη κοινωνικών δεξιοτήτων εκ μέρους των παιδιών, πόσο αποτελεσματική ή βοηθητική μπορεί να είναι για τα παιδιά αλλά και στο κατά πόσο τα παιδιά μπορούν να μεταφέρουν την νέα γνώση στον πραγματικό κόσμο. Η συμμετοχή των παιδιών και των γονέων τους, τα δεδομένα που θα συλλεχθούν αλλά και τα αποτελέσματα που θα εξαχθούν θα είναι εμπιστευτικά και ανώνυμα.

Για την διεξαγωγή της αξιολόγησης θα θέλαμε να πραγματοποιηθεί μια σειρά από συνεδρίες στις οποίες τα παιδιά θα λάβουν μέρος. Στις συνεδρίες αυτές σημαντική είναι η συμμετοχή όσων θεραπευτών το επιθυμούν αλλά και των γονέων των παιδιών καθώς η παρουσία τους θα είναι βοηθητική τόσο για εμάς όσο και για την ευκολότερη και πιο γρήγορη προσαρμογή των παιδιών στο περιβάλλον του εργαστηρίου. Στόχος των συνεδριών είναι η εκπαίδευση και η βελτίωση των κοινωνικών δεξιοτήτων των παιδιών. Το θέμα των συνεδρίων θα εστιάσει στην εκπαίδευση των παιδιών όσον αφορά την ασφαλή διασταύρωση ενός εικονικού δρόμου με στόχο την μεταφορά της γνώσης στον πραγματικό κόσμο. Συγκεκριμένα πρώτα τα παιδιά θα μάθουν να αναγνωρίζουν και να εντοπίζουν τα κινούμενα αυτοκίνητα, να αναγνωρίζουν και να ερμηνεύουν τα φώτα τροχαίας αλλά και να μάθουν πότε μπορούν ασφαλισμένα να διασταυρώνουν ένα δρόμο.

Θα περιμένουμε με ανυπομονησία την απάντησή σας στην πρότασή μας για συνεργασία του συνδέσμου σας και του εργαστηρίου μας.

Με εκτίμηση,
Σκεύη Ματσεντίδου
Μεταπτυχιακή φοιτήτρια
Τμήματος Πολυμέσων και Γραφικών Τεχνών
Τεχνολογικού Πανεπιστημίου Κύπρου (ΤΕΠΑΚ)
Email: skevi.matsentidou@gmail.com
Τηλ: 99904073

1.2 Informational Letter - Parents

Immersive and Creative Technologies Lab
Cyprus University of Technology
Basement Floor (-1),
Micrologic Building,
31 Le Corbusier Street,
3075 Limassol,
Cyprus

Αξιότιμε/η κύριε/α,

Είμαι μεταπτυχιακή φοιτήτρια του προγράμματος Μάστερ στα Διαδραστικά Πολυμέσα του Τεχνολογικού Πανεπιστημίου Κύπρου. Για την ολοκλήρωση του μεταπτυχιακού προγράμματος που παρακολουθώ καλούμαι να εκπονήσω Μεταπτυχιακή Διατριβή. Στα πλαίσια της μεταπτυχιακής διατριβής μου αναπτύσσω μια διαδραστική immersive εφαρμογή σε VR CAVE περιβάλλον με στόχο την εκπαίδευση και την βελτίωση των κοινωνικών δεξιοτήτων των παιδιών με αυτισμό. Παράλληλα στόχος της μεταπτυχιακής διατριβής είναι να διερευνηθεί κατά πόσο το VR CAVE περιβάλλον μπορεί να χρησιμοποιηθεί αποτελεσματικά στην εκπαίδευση των παιδιών με αυτισμό. Το VR CAVE περιβάλλον βρίσκεται στο Immersive and Creative Technologies Lab (ICT Lab) (http://www.theictlab.org/)του Τεχνολογικού Πανεπιστημίου Κύπρου. Περισσότερες πληροφορίες για το VR CAVE μπορείτε να βρείτε και στη σελίδα http://www.vrcave.com.cy.

Με την παρούσα επιστολή θα ήθελα να εκφράσω την επιθυμία μου για συνεργασία του εργαστηρίου μας με τον σύνδεσμό σας («Ορίζοντας») στην ολοκλήρωση της μεταπτυχιακής αυτής εργασίας. Η συνεργασία και η βοήθεια που μπορεί να μας προσφέρει ο σύνδεσμός σας είναι πολύτιμη για εμάς καθώς χρειαζόμαστε την βοήθεια ενός μικρού αριθμού παιδιών (2-3 παιδιά) αλλά και εσάς των ίδιων (των γονέων των παιδιών) για την διεξαγωγή της αξιολόγησης της εφαρμογής που αναπτύχθηκε. Με την συμμετοχή των παιδιών στην αξιολόγηση της εφαρμογής θα μπορέσουμε να εξάγουμε συμπεράσματα όπως κατά πόσο αυτή η εφαρμογή μπορεί να χρησιμοποιηθεί στην εκπαίδευση των παιδιών, κατά πόσο μπορεί να εμπλακεί αποτελεσματικά στην ανάπτυξη κοινωνικών δεξιοτήτων εκ μέρους των παιδιών, πόσο αποτελεσματική ή βοηθητική μπορεί να είναι για τα παιδιά αλλά και στο κατά πόσο τα παιδιά μπορούν να μεταφέρουν την νέα γνώση στον πραγματικό κόσμο. Η συμμετοχή των παιδιών και των γονέων τους, τα δεδομένα που θα συλλεχθούν αλλά και τα αποτελέσματα που θα εξαχθούν θα είναι εμπιστευτικά και ανώνυμα.

Για την διεξαγωγή της αξιολόγησης θα θέλαμε να πραγματοποιηθεί μια σειρά από συνεδρίες στις οποίες τα παιδιά θα λάβουν μέρος. Στις συνεδρίες αυτές σημαντική είναι η συμμετοχή όσων θεραπευτών το επιθυμούν αλλά και εσάς των γονέων των παιδιών καθώς η παρουσία σας θα είναι βοηθητική τόσο για εμάς όσο και για την ευκολότερη και πιο γρήγορη προσαρμογή των παιδιών στο περιβάλλον του εργαστηρίου. Στόχος των συνεδριών είναι η εκπαίδευση και η βελτίωση των κοινωνικών δεξιοτήτων των παιδιών. Το θέμα των συνεδρίων θα εστιάσει στην εκπαίδευση των παιδιών όσον αφορά την ασφαλή διασταύρωση ενός εικονικού δρόμου με στόχο την μεταφορά της γνώσης στον πραγματικό κόσμο. Συγκεκριμένα πρώτα τα παιδιά θα μάθουν να αναγνωρίζουν και να εντοπίζουν τα κινούμενα αυτοκίνητα, να αναγνωρίζουν και να ερμηνεύουν τα φώτα τροχαίας αλλά και να μάθουν πότε μπορούν ασφαλισμένα να διασταυρώνουν ένα δρόμο.

Θα περιμένουμε με ανυπομονησία την απάντησή σας στην πρότασή μας για συνεργασία, για παροχή της πολύτιμης βοήθειάς σας αλλά και την άδειά σας για συμμετοχή των παιδιών σας αλλά και εσάς των ιδίων στην αξιολόγηση της εφαρμογής αυτής. Σε περίπτωση που ενδιαφέρεστε να συμμετέχετε στην έρευνα αυτή επικοινωνήστε μαζί μου το συντομότερο δυνατό για να διευθετήσουμε μαζί την ημερομηνία για την διεξαγωγή της συνεδρίας. Για οποιεσδήποτε πληροφορίες ή διευκρινήσεις μπορείτε να επικοινωνήσετε μαζί μου.

Με εκτίμηση,
Σκεύη Ματσεντίδου
Μεταπτυχιακή φοιτήτρια
Τμήματος Πολυμέσων και Γραφικών Τεχνών
Τεχνολογικού Πανεπιστημίου Κύπρου (ΤΕΠΑΚ)
Email: skevi.matsentidou@gmail.com
Τηλ : 99904073

1.3 Consent Form - Parents

Έντυπο Συγκατάθεσης

Ημερομηνία:

Εγώ ο/η, ____, ως γονέας παραχωρώ με το παρόν έγγραφο την άδεια συμμετοχής του παιδιού μου αλλά και εμένα του ιδίου στην σειρά συνεδριών που θα πραγματοποιηθούν με στόχο την αξιολόγηση της εφαρμογής που αναπτύσσεται στα πλαίσια της Μεταπτυχιακής Διατριβής με τίτλο “Towards Effective Immersive Visualizations for the Training and Enhancement of Social Skills for Children with Autism” του μεταπτυχιακού προγράμματος Διαδραστικά Πολυμέσα του Τμήματος Πολυμέσων και Γραφικών Τεχνών του ΤΕΠΑΚ.

Με το παρόν έντυπο διαβεβαιώνεται ότι η συμμετοχή σας είναι εμπιστευτική και ανώνυμη, τα δεδομένα που θα συλλεχθούν αλλά και τα αποτελέσματα που θα εξαχθούν θα χρησιμοποιηθούν μόνο για σκοπούς έρευνας και μόνο από τους δημιουργούς και αξιολογητές της εφαρμογής.

Υπογραφή συμμετέχοντα	Υπογραφή ερευνητή
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1.4 Consent Form - Educators

Έντυπο Συγκατάθεσης

Ημερομηνία:

Εγώ ο/η, ____, παραχωρώ με το παρόν έγγραφο την άδεια συμμετοχής μου στη διαδικασία αξιολόγησης της εφαρμογής που αναπτύσσεται στα πλαίσια της Μεταπτυχιακής Διατριβής με τίτλο “Towards Effective Immersive Visualizations for the Training and Enhancement of Social Skills for Children with Autism” του μεταπτυχιακού προγράμματος Διαδραστικά Πολυμέσα του Τμήματος Πολυμέσων και Γραφικών Τεχνών του ΤΕΠΑΚ.

Με το παρόν έντυπο διαβεβαιώνεται ότι η συμμετοχή σας είναι εμπιστευτική και ανώνυμη, τα δεδομένα που θα συλλεχθούν αλλά και τα αποτελέσματα που θα εξαχθούν θα χρησιμοποιηθούν μόνο για σκοπούς έρευνας και μόνο από τους δημιουργούς και αξιολογητές της εφαρμογής.

Υπογραφή συμμετέχοντα	Υπογραφή ερευνητή
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1.5 Questionnaire for Educator

<u>Your experience</u>

How easy was it for you to understand and learn how to handle the xbox - hand controller and its functionalities (how to navigate in the environment and sent the appropriate signals during the training)?

____

____

Did you face any problem or difficulties with the way of navigation in the environment?

____

____

Did you face any problem or difficulties with the control of the lesson/how to handle the training? (e.g., How to stop cars?)

____

____

Did you face any problem during the training?

____

____

Is there something that needs to be changed, modified, added or removed in your opinion?

____

____

<u>Children and Training</u>

Do you think it could help children with autism to learn how to cross the road safely?

____

____

Do you think it could help children with autism in any other way?

____

____

Do you believe children will accept (fill comfortable) with the system and devices and they will be able to interact with it, and use them?

____

____

What difficulties or problems do you believe children might face?

____

____

Do you believe children could perform the appropriate activities in each part of the session? Will they be able to complete the parts of the session successfully?

____

____

Do you believe children could focus and concentrate on the system and session?

____

____

Do you believe children could follow the instructions of the educator during the session?

____

____

What are the advantages and/or disadvantages of this way of training children with autism? Especially for this purpose (learn how to cross the road).

____

____

Which existing method would you use for educating children with autism about crossing the road safely? Could the approach with VR CAVE offer something more? Which of the two approaches do you believe would lead to the desired effect?

____

____

Would you use those two approaches in combination?

____

____

Is there something else you want to mention about the application in the VR CAVE environment or about the training with that?

____

____

<u>Personal Information</u>

Select the right answer:

Gender:

Male	Female

Your relation with technology, you say that it is:

Excellent	Very Good	Medium	Little Good	Poor

Specialization:

____

1.6 Observation children without autism

Evaluation of the VR CAVE environment

Number:	
Age:	

Note with √:

	Yes	No
Do you know how to cross the street alone?		

	Boy	Girl
Gender:		

Observation

Difficulties, Problems	
Behaviours, Fillings, Imagination	
Actions, Activities	
Samples show that feel like holds the system control or immersed himself	
Samples of excitement (e.g. laugh, smile) – enjoy, satisfaction, comfortable	

Samples of dissatisfaction, rankled, resents, dislike, uncomfortable	
Complete the session/ errors/ wait at red/ cross at green/ see if cars stopped?	

1.7 Observation children with autism

<u>Evaluation of the VR CAVE environment</u>

Number:	
Age:	
Autism Level:	

Note with √:

	Yes	**No**
Does the child know how to cross the street alone?		

	Boy	**Girl**
Gender:		

Accept of	**Yes**	**No**
System		
Devices (glasses)		
Shoes		

Positive fillings	**Yes**	**No**
laugh		
smile		
enjoy		
excitement		
satisfaction		
comfortable		
other		

Negative fillings	**Yes**	**No**
dissatisfaction		
Rankled (δυσανασχέτηση)		
Resents (αγανάκτηση)		
dislike		
uncomfortable		
other		

Communication (educator or other people)	**Yes**	**No**
body		
verbal		

	Yes	No
Realize/perceive of their body **- Samples**		

Difficulties, Problems	

Samples of focus / attention to system	
Samples show that feel like holds the system control or immersed himself	

Facial Expressions	
Imagination	
Behaviours or Stereotypical Behaviours	
Actions, Activities	

Session

	YES	NO	A part of it
Complete the session?			
Completion time			

Part A - Cars

	YES	NO	A part of it
Complete Part A?			
Number of Tries			
Number of errors			
Kind of errors			

	YES	NO
Recognize, identify cars?		
Track them? (watch, follow)		
Avoid moving cars? (αποφεύγω)		
Notes		

Appropriate responses	Yes	No
carry out instructions		
follow instructions		
head shake		
eye contact		
pointing		
Other (e.g. listening)		

Inappropriate responses	Yes	No
no responses		
lack of eye contact		
lack of focus		
no response to instructions		
topic change		
other		

Part B – Crossing Button

	YES	NO	A part of it
Complete Part B?			
Number of Tries			

Number of errors	
Kind of errors	

	YES	**NO**
Recognize the crossing button?		
Find, identify it?		
Walk and stop to it?		
Press it?		
Wait after press it?		
Notes		

Appropriate responses	**Yes**	**No**
carry out instructions		
follow instructions		
head shake		
eye contact		
pointing		
other		

Inappropriate responses	**Yes**	**No**
no responses		
lack of eye contact		
lack of focus		
no response to instructions		
topic change		
other		

Part C - Lights

	YES	**NO**	**A part of it**
Complete Part C?			
Number of Tries			
Number of errors			
Kind of errors			

	YES	**NO**

Recognize, find, and identify the lights?		
Understand the meaning of the lights? (after the explanation, wait at red, walk at green?)		
Focus on them?		
Wait when light is red?		
Focus/see on cars when those have stopped?		
Notes		

Appropriate responses	Yes	No
carry out instructions		
follow instructions		
head shake		
eye contact		
pointing		
other		

Inappropriate responses	Yes	No
no responses		
lack of eye contact		
lack of focus		
no response to instructions		
topic change		
other		

<u>Part D - Crossing</u>

	YES	NO	A part of it
Complete Part D?			
Number of Tries			
Number of errors			
Kind of errors			

	YES	NO
Recognize, find, and identify the crossing?		

Focus on it?		
Focus/see on green lights? Check if lights are green?		
Focus/see on stopped/ stationary cars?		
Turn head – right, left **(check** if **cars** are **stopped?**)		
Walk to crossing if he can? According to lights and cars? – Cross the road?		
Notes (e.g. samples show understanding or not, responses)		

Appropriate responses	Yes	No
carry out instructions		
follow instructions		
head shake		
eye contact		
pointing		
other		

Inappropriate responses	Yes	No
no responses		
lack of eye contact		
lack of focus		
no response to instructions		
topic change		
other		

Part E – Crossing alone without help – All the session from beginning

	YES	NO	A part of it
Complete Part E?			
Number of Tries			
Number of errors			
Kind of errors			

	YES	NO
Recognize, find, and identify cars, button, lights, crossing?		

Track and avoid moving cars?	
Bush button?	
Focus on lights? Wait when lights are red? Wait when cars moving?	
Focus/see on green lights?	
Focus/see on stopped/ stationary cars? - looks **right** and **left** with his **head** to **check** if **cars** are **stopped?**	
Walk to crossing if he can? According to lights and cars? – Cross the road?	
Understand the meaning of lights and when it's ok to cross the road?	
Notes (e.g. samples show understanding or not, responses)	

Appropriate responses	Yes	No
carry out instructions		
follow instructions		
head shake		
eye contact		
pointing		
other		

Inappropriate responses	Yes	No
no responses		
lack of eye contact		
lack of focus		
no response to instructions		
topic change		
other		