Interactive Sensory Program for Affective Learning (InSPAL): An Innovative Learning Program Combining Interactive Media and Virtual Reality for Severely Intellectually Disabled Students

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Abstract. While special educational and training programs have been developed specifically for severely intellectually disabled (SID) students; little research has been carried out that employs the latest advances in virtual reality (VR) technology and 3D motion recognition for this population of students. In this study we focus on the development of a unique psycho-educational program called Interactive Sensory Program for Affective Learning (InSPAL) that exploits natural interface and virtual reality technologies together with pedagogically designed VR learning scenarios to enhance the pre-learning skills of SID students. The InSPAL program offers to SID students an environment in which to actively interact with the virtual learning scenarios, communicate in an alternative way, and develop a sense of mastery enhancing their learning potential. This paper will highlight the learning objectives, the instructional design and training flow for two of the learning domains of the InSPAL program. Our preliminary observations show that the SID students demonstrated an ability to interact with the virtual learning scenarios and many were able to communicate by raising their hands post training.

Keywords: Interactive media, virtual reality, severely intellectually disabled, psycho-educational learning scenarios.

1 Introduction

The application of Virtual Reality in education is beginning to gain attention in some General Education environments [1], but little work has been carried out in Special Education Settings, especially those serving Severe Intellectual Disabilities (SID) students with significant learning challenges. In response to this, City University of Hong Kong (CityU) has undertaken the research and development of an Interactive Sensory Learning Program called InSPAL for the severely intellectually disabled (SID) students, who are having cognitive deficiencies and other sensory-motor handicaps, and thus need more help and attention in overcoming their learning

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difficulties. Through combining and integrating interactive media, 3D motion capture, and virtual reality technologies with the principles of art therapy and relevant pedagogical techniques, InSPAL aims to strengthen the SID students' pre-learning abilities, promote their self-awareness, decrease behavioral interferences with learning as well as social interaction, enhance their communication and thus promote their quality of life.

Individuals with severe intellectual disabilities (SID), otherwise known as severe mental retardation (SMR) constitutes an intellectual impairment IQ range between 20 to 35; with marked limitations in cognition, self-care, communication, and social/interpersonal skills [2].

One primary aspect that impedes the learning for SID students is the lack of ability for many to communicate and interact effectively with others, as well as to focus and engage in the educational activity for an extended period of time. The current use of Speech, Occupational, and Physical Therapy Programs are well recognized as a viable means to improve the overall functioning of SID students. Alternative programs in education and training are being developed and carried out for children with mild to moderate disabilities, virtual reality (VR) being one of them. The use of virtual reality and interactive media can be an authentic tool to stimulate appropriate affect (e.g. curiosity, motivation, attention) for learning and to integrate and bridge internal and external realities [3]. The application of VR to children with disabilities helps to improve social-emotional capability [4] as well as develop a sense of self-control over multisensory stimulation and mastery [3], [8]. VR offers a learning mode that is experientially based enabling the learner to be immersed in the virtual world and can require less mediation from the teacher/facilitator [5]. Our InSPAL program offers to SID students a novel learning environment in which to actively interact with the virtual scenarios, communicate in an alternative way, and develop a sense of mastery and self-esteem, enhancing their learning potential.

2 Learning Objectives and InSPAL Learning Scenarios Design for SID Students

In this project, the scope of the key learning objectives for SID students are as follows: 1) To increase attention span 2) To induce curiosity 3) To learn to differentiate 4) To increase articulation/verbal expression 5) To increase body coordination and visual tracking. Based upon these learning objectives, eight learning scenarios have been developed within the framework of four learning domains 1) Safety awareness 2) Cause and effect 3) Balance 4) Sensational experience. Due to the limitation of space, in this paper, we will focus on the research and design of the learning scenarios and psycho-education sessions with the students for two of the learning domains, namely Safety Awareness Domain and the Cause and Effect Domain.

2.1 InSPAL Psycho-Education Session Design and Programme Schedule

We are currently conducting the main core of the INSPAL learning programme for SID students in collaboration with The Mental Health Association of Hong Kong – Cornwall School, and have developed a training protocol for the InSPAL classes.

The psycho-educational sessions involve 8 classes of SID students scheduled in an 18 months period, which include 4 sub-periods. Two classes would take part in each sub-period which approximately last for 5 months. In each sub-period, a class would go through a preparation programme which allows the SID students to accustom to wearing the 3D viewing glasses, and then work through 2 learning domains. Each learning domain last for 2 months and each class had 2 training sessions each week on the average, making it a total of 16 sessions for each domain, and a total of 32 psycho-educational training sessions.

Working in close collaboration with teachers and staff of the collaborating school, we have been able to fine-tune the InSPAL training protocol based upon our continued exposure to the varying levels of cognitive and physical functioning of the students, and specified behavioral objectives that we have identified whilst working with them. The flow of Psycho-education sessions for the Safety Awareness Domain is presented below.

2.2 Learning Domain 1: Safety Awareness Domain

Most SID students are not aware of the importance of safety, which impedes their overall functioning and ability to take some control of their environment and make healthy choices. Safety awareness is a key concept needed for SID students in order for them to be able to navigate safely at school and at home. Through training, students can learn to decipher between safe and unsafe items and what to touch and not touch. InSPAL interactive scenarios allow students to learn about safety standards within the safety of the VR space. The benefit of offering a VR space is that if students make a mistake and touch an unsafe item, they will not 'get hurt'. The InSPAL learning environment enables students to learn the concept of safety in a 'safe environment'.

Learning Scenario 1: Safety at School. The learning objectives for this learning scenario are as follows: 1) To learn to differentiate between safe and unsafe items within the school environment. 2) To make decisions as to what is safe to touch and what is not safe to touch. 3) To enhance the adaption of appropriate behaviour within the environment.

In the *Safety at School* Scenario, students will be immersed in a school virtual space consisting of a variety of safe and unsafe items in their view. Such items will range from plants to sharp items such as scissors/ or slippery conditions. With the support of the teacher/facilitator, students will learn to distinguish between safe/unsafe items and select only to touch safe items using simple hand gestures. Figure 1 shows a sample screen of the *Safety at School* virtual space.

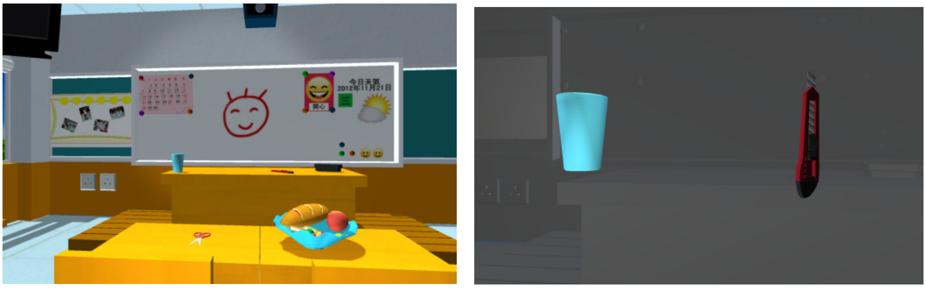

Fig. 1. Safety at School Learning Scenario. (Left: a classroom scene containing safe and unsafe objects; Right: One safe and one unsafe object were highlighted for the student to choose)

Learning Scenario 2: Safety at Home. The learning objectives for this learning scenario are the same as those for the learning scenario Safety at School except it is designed for the home environment.

In the Safety at Home Scenario, students will be immersed in a home virtual space consisting of a variety of safe and unsafe items in their view. Such items will range from a teddy bear sitting on a sofa/ or pillows to a gas stove with lit fire/ or electricity coming out of the socket to a bottle of pills. With the support of the teacher/facilitator, students will learn to distinguish between safe/unsafe items and select only to touch safe items using simple hand gestures.

Psycho-education Sessions for the Safety Awareness Domain. The flow of InSPAL training session involved working with each student individually. Referring to Figure 2,

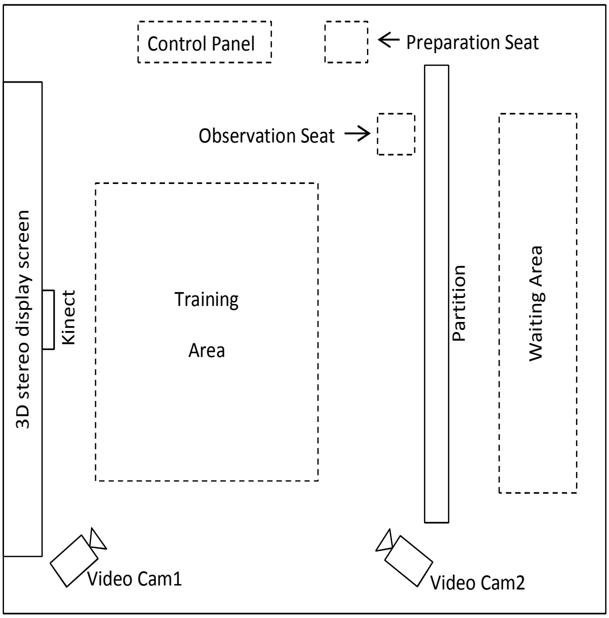

Fig. 2. InSPAL Scenario Training Environment

each student enters the InSPAL playing area (wearing the 3D glasses) and is first given a demonstration by the trainer of the interaction activity with the virtual 3D classroom scenario. The virtual classroom scene zooms into a pair of items, one which is a safe item and the other unsafe (see Figure 1). The trainer "points" only to the safe item, while at the same time verbally stating that this item is safe. This is then repeated for other pairs of safe and unsafe items. After all pairs of items have been shown, the demonstration is completed. After the demonstration, the student is given an opportunity and encouraged to select each pair of safe items in the classroom setting as s/he has seen in the demonstration. If the student cannot select on his/her own, the trainer supports the student to select the safe item using a hand on hand support technique. Each training session with the student consists of 2 demonstrations by the trainer and 2 practice sessions for the student.

2.3 Learning Domain 2: Cause and Effect Domain

Another key concept needed for learning is the concept of Cause and Effect. A majority of SID students are passive and wait for their teachers and caregivers to carry out tasks and meet their needs. For example, "Raising my hand will have the effect of the teacher knowing that I need to go to the toilet." By strengthening this concept in students, they can begin to meet their own needs, learn that there is a consequence and increase their ability to take some control of themselves within their environment. The InSPAL learning environment enables students to experience and practice this concept of cause and effect in 3D space, and once acquired, this skill can be transferred into the classroom setting and home environment.

Learning Scenario 3: Touch to Change. The learning objectives for this learning scenario are as follows: 1) To experience seeing in 3D space the effect of touching something (cause and effect). 2) To practice controlling their body and satisfying their needs. 3) To increase articulation/verbal expression.

The consultant/trainer worked to train the SID students to raise their hands to 'touch' the virtual bubbles (cause); the effect of touching the bubble is that the virtual bubble will burst. After touching and bursting five bubbles, a big beautiful happy face

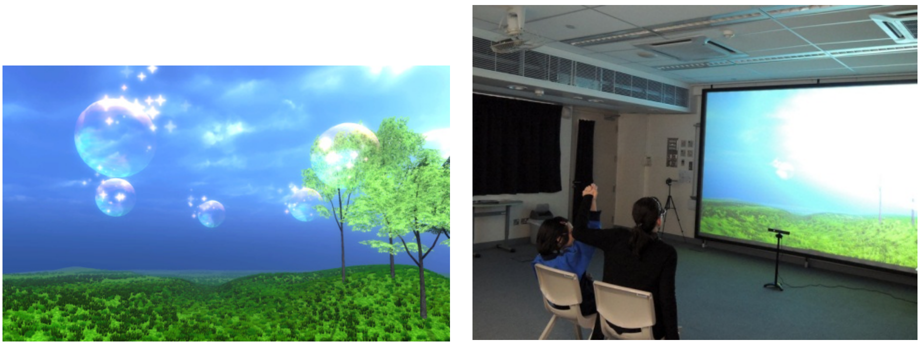

Fig. 3. The 'Touch to Change' virtual learning scenario

would emerge on the screen, along with happy music, giving positive feedback to the student for their success and experiencing the cause and effect process. Figure 3 shows a sample screen of the Touch to Change virtual 3D scene.

Learning Scenario 4: Coloured Balloon Sculpture. This was much like learning Scenario 3 except that it entailed a more complex visual outcome, further engaging the students into the cause and effect experience. The flow of the training followed the same as the above, except in this scenario the students were trained to raise their hands touch the virtual balloons and could experience the effect of touching the balloon in that it would burst, transforming into an object/ or animal (ie) teddy bear, flow in mid-air and then fall to the ground, making it a sensational outcome.

Psycho-Education Sessions for the Cause and Effect Learning Domain. The flow of training session involves working with each student individually. Again referring to Figure 2, each student enters the InSPAL playing area (wearing 3D glasses) and is given a demonstration by the trainer. After the demonstration, the student is given an opportunity and encouraged to raise his/her hand to reach the bubbles. If needed, the trainer would provide a hand on hand technique (see Figure 3) to train the student to raise his/her hand until all 5 bubbles were popped and the ‘happy face’ appeared. This procedure would continue for 3 rounds. Each time the student came to engage in the Touch-to-Change Scenario, they were encouraged to reach for the bubbles independently, giving them autonomy in the cause and effect experience.

3 The InSPAL Learning Environment

An InSPAL classroom was designed and installed in The Mental Health Association of Hong Kong – Cornwall School (MHAHK) to support the interactive sensory programme with the provision of different modalities of interactive multimedia and 3D stereo display, including hardware, software, installation materials, sensor and interactive device which were shown in figure 5.

3.1 The Hardware and Software

The hardware – computing equipment enabled the implementation of the graphics rendering programme and the processing of input data from the sensor and interactive device. The input data is provided in the form of body joint positions (i.e. the head, hands and upper body movements) in 3D space, i.e. the actual environment. To achieve real time interactions, the commonly available motion sensor Kinect was used as the main sensor and interactive device.

The software includes the development of robust and custom-made algorithms to capture and recognize the body gestures (e.g. raising hand, pointing and weight shifting actions) of SID students in order to enable them to take control of the interactions with the virtual environment in the learning scenarios.

3.2 3D Stereo Display

To provide a vivid virtual environment, the 3D stereo system played an essential role in the InSPAL learning environment design. The system consisted of 3D stereo projection facility, silver display screen and 3D viewing glasses. The system applied both circular polarization filters and lens to enable the display of 3D effects in abnormal viewing positions, including head titling which is commonly seen in the SID students due to their physical limitation. A 3D silver display screen was installed to compensate the reduction of illumination caused by polarization filters and provide a bright and clear 3D display. The polarized 3D viewing glasses were designed and configured that would be suitable and comfortable to be worn by the SID students.

3.3 Working Environment

For the working environment setting, a partition screen was set up to separate out a waiting area for the students waiting to work with the 3D learning scenarios from those who were, at the time, working with the learning scenarios. The partition serves to reduce the possibility of the students who were working with the 3D scenarios, whose attention might be distracted by those waiting in the same room. The resulting working environment as shown in Figure 4 had been proven effective in the training sessions.

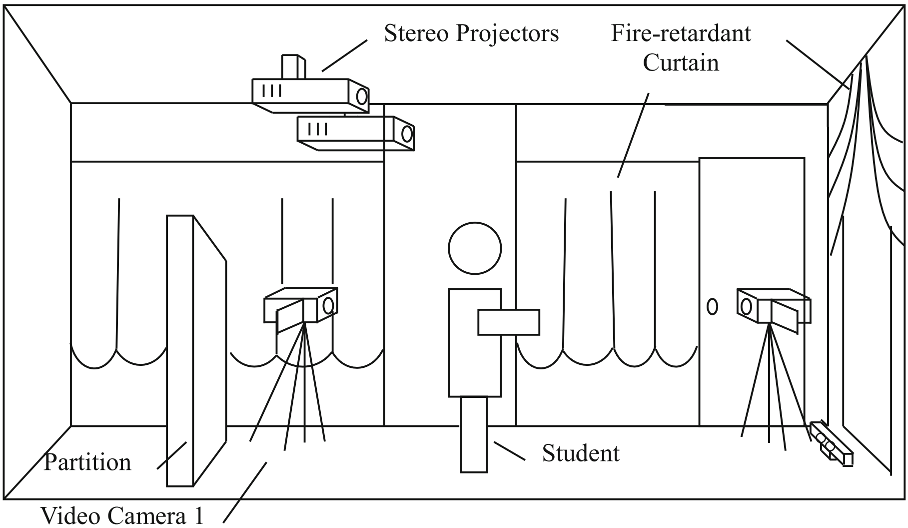

Fig. 4. A schematic of the InSPAL Learning Environment

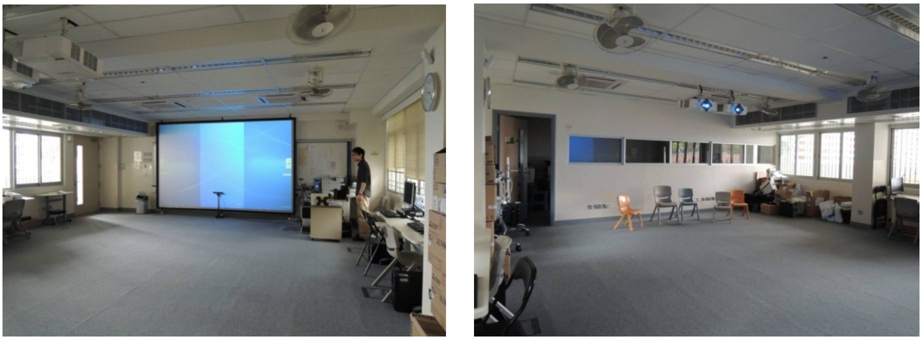

Fig. 5. The InSPAL Classroom

4 Conclusion

We are currently in the process of conducting the year-long InSPAL training programme. The preliminary observations are that most SID students have had a positive experience with the InSPAL program. They showed levels of excitement whilst seeing the virtual **environment** and experiencing new activities that they would not normally encounter in their day to day learning environment (ie) navigating through virtual space via reaching to touch objects that 'pop' and fall to the ground, transforming into another object.

At the beginning of the training sessions many of the students looked at the screen using peripheral vision but later they would look at the screen straight on and become more focused. For those students who exhibited behavioral/ or emotional issues in the conventional classroom, they also showed similar behaviors in the InSPAL training sessions. Close partnership with the teachers enabled us to make improvements in these areas, helping to strengthen their learning potential.

Overall, the teachers responded that the training students received had a positive outcome in two areas: 1) Greater ability to interact with the learning scenarios and 2) More students able to raise their hands post training.

The InSPAL program encouraged SID students, through interactive communication with the virtual reality scenarios and the teacher/trainer, to learn to interact and communicate, increase attention span and engage in self-control. Our working hypothesis is that through these activities with the 3D virtual world, SID students will learn to develop or enhance pre-learning skills preparing SID children to learn and grow in the conventional classroom environment. During the InSPAL session, activity and observational data are collected and video are taken to enable us to subsequently analyse / decipher the efficiency of the training protocol and the learning scenario design.

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