Virtual Reality in Special Needs Early Education

Cecília Sik Lányi, Zoltán Geiszt, Péter Károlyi, Ádám Tilinger and Viktor Magyar

***Abstract*—During recent decades there has been an observable development in the social state of so-termed disabled people. With the WHO's definition on the concepts of handicap, impairment and disability and the light cast on society's responsibility towards their impaired members a radical change started. The overwhelming technological development of the late 20th century has inserted a new dimension into the debate [1]. In the 21st century when almost everybody uses computers it would be better to refer to disabled people as special needs users, since they have the same rights as healthy people to learn, work, and have fun using computer generated virtual environments. The question arises: is the development process of software for special needs users any different?**

In modern educational technology the unity of form and content and their relationship is one of the most prominent issues. This special unity is seen in the promising features of the present day virtual environments. In this chapter we review the relevant literature and describe some new examples that were developed in the University of Pannonia.

***Index Terms*—Virtual reality, special needs education, rehabilitation, virtual classroom.**

I. INTRODUCTION

Virtual reality (VR) and virtual environments (VE) have already been used in special applications to treat motor problems, or disabilities induced by mental problems with promising results. Only a short list of such works is shown here: Treatment of phobias [2]; Manipulation of wheel chairs for children [3]; Body image disturbances [4]; Head injury [5]; Parkinson disease [6], and Autism [7]. The psychological field has also been targeted by other applications using VE, for example helping cancer patients come to terms with their disease [8]. Attentional retraining and perceptuo-motor skills reacquisition were also the focus of work by Wann et al. [9]. However VE applications are still limited in the areas for which they have been developed and there is a desperate need for them in education, especially in the special needs quarter. Although VR technology has been available for at least ten years, literature concerning its use in special needs education is limited. A search for articles on this topic in the most relevant journals for example Presence Teleoperators and Virtual Environment [10], Virtual Reality [11], JAMIA [12], Pediatrics [13], Computer & Graphics [14], Journal of IT Education [15] produced almost nothing. There are only a few publications in the latest conference proceedings.

Standen and Brown wrote a paper on general issues of Virtual Reality in the Rehabilitation of People with Intellectual Disabilities [16]. Takacs gave a detailed summary on "Special Education & Rehabilitation" and described their new virtual environment and emotional avatar [17]. This paper presents a unique human-computer interface, which uses reactive, animated human models. Such agents help to create a personal relationship and make the application more effective due to the emotional modulation method. The human models are endowed with perceptive abilities: a deep-layer communicative intelligence and a surface artificial vision. The goal was to imitate the exchange of human information by the amalgamation of surface computer animation, perception and deep-layer artificial intelligence.

II. BACKGROUND

Obviously the use of an artificial agent, like that of Takacs requires higher computational capacity from the hardware. But nowadays there are computers with sufficient processing capability in schools, even in developing countries. These computers are able to display the virtual environments of tomorrow, including Takacs's tutor agent [17] thus opening up many new opportunities for the use of VE-s in special needs education.

A. Virtual Environments for visual impaired or blind children

The research of Sánchez and Lumbreras [18] aimed to investigate usability and cognitive issues in a purely aural environment. They focussed on the analysis of the creation of mental structures of a navigable object using only spatial audible information and no visual information. Eleven children took part in the six months long project in a Chilean school for blind children. Among the tasks were ones based on cognitive representation, including corporal exercises, acting in a 3D acoustic environment and experiences with concrete representational materials such as clay, sand, Styrofoam, and Lego bricks. The findings of the research showed that 3D sound alone is enough for the construction of mental structures suggesting that spatial imagery is not dependent purely on visual information.

Their case study pointed out that embodiment in virtual environments provides a link between cognition and experience: abstract concepts are based on bodily experience. In addition it was also shown that the cognition and building of structures in a virtual environment follows the same pattern as its every-day counterpart: the categories become containers and hierarchies become spatial structures [19].

Another virtual environment, Audio Math was developed not only for, but by blind children. This unique feature allowed its test by its very developers during and after implementation.

Manuscript Received on November 5, 2006
University of Pannonia, 8200 Veszprém, Egyetem u. 10, Hungary
e-mail: lanyi@almos.vein.hu

The results provide evidence that sound can be a powerful interface to develop and enhance memory and the learning of mathematics in blind children [20].

Sánchez conducted another study with sound-based virtual environments which looked at the development of abstract memory through spatial reference. Abstraction through concrete representations was focused on the cognitive integration of both spatial and haptic references. Audio Battleship, as this application is called, showed that this was process was very useful in forming mental images of space, haptic perception, abstract memory, and spatial abstraction [21].

The European Media Master of Arts program of the Utrecht School of the Arts (Arts, Media & Technology) and the Barteméus Accessibility Foundation in Zeist have developed a curriculum for accessible game and program development together. Courses following this curriculum have already produced a branch of spectacular games like Drive, The Curb Game, Hall of Sound, Powerchords, Wow, Demor and others. The program has been developed through working with user panels and extensive user testing [22].

B. Virtual Environments for physical disabilities

Spatial problems can also be experienced by children with physical disabilities that limit their autonomous movement. Due to this, they are not likely to be able to fully explore environments, which is also a problem for those who need some form of assistance (wheelchair, transport by a carer, etc). They may also have limited access, and may rely on their assistant to choose routes. Studies on cognitive spatial skills have shown that children with mobility limitations have difficulty forming effective cognitive spatial maps [23].

A new VE was developed to train these children. It consisted of a simulated “maze” comprising four rooms linked by runways to be explored by the participants. Then in a test they had to take shortcuts between target room locations [23]. The experimental group consisted of 7 physically disabled children, 6 boys and one girl took part in this project, with a mean age of 12.3 years. This and Stanton’s former studies showed that repeated exposure to VE of the same complexity significantly improved children’s skills of orientation and spatial navigation [24]. The most rigorous test of the VE’s efficiency will be a real situation in which the children could show their achievements in navigation.

A simulation system for powered wheelchairs was developed in France [25]. Its aim was to help to find the wheelchair that matches the locomotive disability of any given user. The system has a fixed base platform and a simulator.

Early childhood is a very important period in terms of spatial navigation; it is the time when spatial perception and cognitive abilities develop through independent mobility. But mobility impairment highly impedes such actions which lead to negative consequences. To help solve this problem a VE was developed which allowed a highly flexible, personalised training. As the system was dynamically modifiable to recognise the users’ strengths and weaknesses in wheelchair control, the training became more effective [26, 27, 28].

As a further aid for individual training, architecture for “Remote Monitoring” in a networked Virtual Environment Mobility Simulator (VEMS) was developed to train powered wheelchair users. Some children are more relaxed when allowed to use a training program alone, and this system permits this with a half hidden remote supervision. An easy-to-use wheelchair DX-joystick interface for exploration and navigation in the VE and the incorporation of game elements led to an observable benefit for severely disabled children at St. Gabriel’s School, Limerick. In addition the experience given by the project opened new ways of overcoming some typical problems in training programs [29].

But virtual environments are not the only computer-generated tool for special treatments; augmented environments also have great significance. While the former ones are completely artificial, the latter ones only augment the real physical environment with additional imagery, properties or information [30], although these augmenting elements may take the form of virtual objects within the real environment. A good example of augmented environments is the virtual music instrument developed at the largest children’s rehabilitation hospital in Canada. This enables children with poor motor control (hypotonia, etc.) to make music via bodily movements, both as a structured educational activity and an unstructured play activity [31].

As it can be seen this VE used a special way of control via ‘capturing’ body movements. But what about the ordinary tools of control? Standen and her colleges investigated the use of keyboard, mouse and joystick. They created four VE-s, resembling dynamic games, with different possibilities of movement to test the variety of uses of the control devices. 17 men and 23 women aged between 21 and 67 participated the test, which conducted in the end that for sole navigation, the joystick was more useful than the keyboard while in interaction the mouse was suggested to be the best [32].

C. Virtual Environments for hearing and speech impaired children

The goal of Passig [33] and Eden’s study was to examine the influence of an intervention program, practicing spatial rotation in a Virtual Environment (VE), on the structure -inductive thinking among hearing-impaired children. The participants were 44 hearing-impaired children of 8-11 with a hearing loss in the better ear ranged from 50 dB to 120 dB, and also a handful of hearing children. Three groups were formed: the hearing impaired was divided into an experimental and a control group, while the hearing children formed a second control group. Each subject in the experimental group was given 15 minutes once a week over a period of three months to play unguided a VR 3D Tetris game, involving the rotation of objects in space. Children in the hearing-impaired control group played with a regular non-virtual 2D Tetris game involving rotation for the same period of time. The subjects of the normal hearing control group were given no rotation tasks. The VR hardware used in this research was a virtual reality interactive game, with software that is able to create a three-dimensional environment. The software included three games (Tetris, Puzzle and Center-Fill), in all of which the objective was to carry out certain demands via control over three-dimensional blocks. Their results indicate that the hearing-impaired improved in structural inductive processes and flexible-thinking ability, using a virtual environment. In addition to this finding, which is important in itself, the research showed that the structural induction skill had improved to the point where hearing-impaired children reached the levels of normal hearing ones. Another important contribution is the advancement of the ability to think in a flexible way to the point where hearing-impaired children almost reached the level of hearing children [33].

A multilingual, multimodal speech teaching and training system was developed for 5-10 year old children with speech problems in a SPECO Project. This system exposed the patients to both speech pictures and sounds of the reference speech, thus using both visual and auditory elements. The efficiency of the system was shown not only by collected opinions of therapists who had used it for a considerable period, but also by an objective experiment [34].

A common suggested treatment for verbal apraxia is repetition accompanied by slow speech. This latter can be produced by time-scaling speech of normal speed, so long as it is of a very high quality. Using such characteristics of speech as the relative durations of speech segments and their variation with speaking rate a new method of time-scaling was developed in Ireland achieving the required quality of output [35].

D. Virtual Environments for autistic children

Autism is a pervasive developmental disorder [36], (WHO) [37], altering both verbal and non-verbal communicative abilities.

Targeting primarily the visual perception a “Returning Home” scenario was developed in Greece for autistic children. In the form of simulated environment it helps the educator to create a coherent organisation of certain important everyday activities [38].

The AURORA project [39] discussed the problems of creating interactive robotic systems for therapeutic purposes in teaching of children with autism. It is hoped that such virtual learning environments will aid the rehabilitation process, and through refinement for each individual patient provide an enjoyable ‘toy’ and increase quality of life [40].

Moore and his co-workers used a collaborative virtual environment (CVE) to analyse the ability of children with autism to understand basic emotions represented by a humanoid avatar. They carried out two empirical studies, whose results suggest that children with autism may be able to accurately recognise emotions in virtual representations. This strengthens the position of CVE as an effective tool of rehabilitation of autism and [41].

Herrera and Vera [42] developed a Virtual School to teach autistic children. Where the following concepts can be worked on:

- Rutter [43] recommends that interventions in autism focus on specific aspects of the three impairments that characterise autism: communication, socialisation and lack of flexibility/ social imagination [44].

There are also other groups using VR for autism whose training focuses on:

- Social abilities [45],
- Autonomy tasks [38],
- Abilities that would be potentially hazardous to be trained in reality, such as crossing the road [46].

E. Collaborative Environment and social skills

Almeida and Ramos described a reference architecture for a multi-user virtual communication platform to help the rehabilitation and social integration of Down’s Syndrome children. It is based on an on-line virtual collaborative environment, equipped with collaboration and interpersonal communication devices and data collection mechanisms to provide management information for the evaluation of the system. It connects children with Down’s Syndrome all over the world through a virtual platform of communication and shared construction processes [47].

The AS Interactive project has focused on supporting the teaching of social skills for people with autistic spectrum disorders (ASDs) through developing a series of Virtual Environments (VEs) [48]. These VE-s contain places and situations with various levels of social difficulty, for example a bus or a café where the user must find an appropriate seat. For further detail, see [49]. The researcher’s observations lead them to describe a definite need for a close connection between the designers and the ‘experts’ in the field under study (teachers, training practitioners, etc.) in design processes. This approach allows the exploration of the potential of VR as a teaching tool and a close look at the possible ways of refining it to be consistent with existing teaching methods. During the months of data collection the teachers became familiar with the technology and able to give more precise directions to the designers. They came up with increasing numbers of suggestions and put them into practice in the classroom [50].

A further step remotely supervised therapies is the use of the internet. In terms of treatments for motor disorders, the range of motion, its dynamism, flexibility and strength can be assessed via a remote force feedback device. Such robotic device can be implemented in a cooperative remedial program further widening the field of use. Some problems arise from the time delay between response and feedback leading to a possible borderline instability. However, using wave variable encoding for velocity and force information, this problem can be dealt with. Under wave variable control, a system of robots 500 miles apart suffers from little time delay: packet loss was less than 1% at transfer rates of 100 Hz with UDP transmission [51].

F. Virtual Class to test ADHD and fear of public speaking

The first effort of Rizzo’s research group in this field included the creation of a virtual environment imitating an ordinary class room. They investigated children’s attention performance while exposed to typical distracter factors, i.e. they assessed Attention Deficit Hyperactivity Disorder ADHD. The environment took the form of a rectangular class room with its ‘typical residents’: a male or female teacher and the group of pupils. The room also had typical furniture and fittings: a table on the front wall, a large window looking toward a crowded street on one of the side walls and a pair of doorways on the other. The user sits at a real desk while immersed the environment with the use of a HMD. Typical classroom distracters (ambient classroom noise, pupil motions, outside events on the street, etc.) were systematically controlled and manipulated in the VE.

On-task attention can be measured via performance (reaction time) using a variety of adjustable attention challenges. These can vary from a simpler focused or selective attention task, such as pressing a button upon hearing the name of a specific colour, to a more complex task of alternating or divided attention, such as responding when the target colour is mentioned but only if another item e.g. an animal, is present. Sustained attention can also be gauged by changing the time demands. With the use of strategically located trackers correlated behavioural measures can be taken as well as measurements of impulsive non-task behaviours [52, 53].

Fig. 1. View from the first floor.

ADHD children's behaviour was compared to normal children's behaviour in this virtual classroom, and the results showed the validity of the VE: ADHD children made more commission errors, had higher levels of body movement, and were more negatively impacted by the distraction factors than normal children.

According to the American Psychiatric Association [54], fear of public speaking is the third most common psychiatric disorder [55]. Slater and colleagues targeted anxiety in general by a study assessing the level of immersion in VR environments and its affect on anxiety [56]. In a further study they asked the subjects with anxiety to give 5 min. presentations to a virtual audience of eight male avatars. The audience was neutral to the subject, remaining static throughout the talk, or positive, i.e. friendly and appreciative in manner, or negative, i.e. displaying hostile and bored expressions [57].

Our idea was to combine these two applications: virtual class and VE for the treatment of public speaking. It is described in the next section. Our virtual class can be used for practising public speaking in a vide range of schools.

III. VIRTUAL ENVIRONMENTS DEVELOPED AT THE UNIVERSITY OF PANNONIA FOR SPECIAL NEEDS EDUCATION

More then 40 software packages have been developed for rehabilitation and education of special needs users in the past ten years in our laboratory. The use of these rehabilitation programs are not restricted to Hungary, they have crossed national borders. The following chapters give some examples, but lays emphasis on the virtual class developed for practising public speaking.

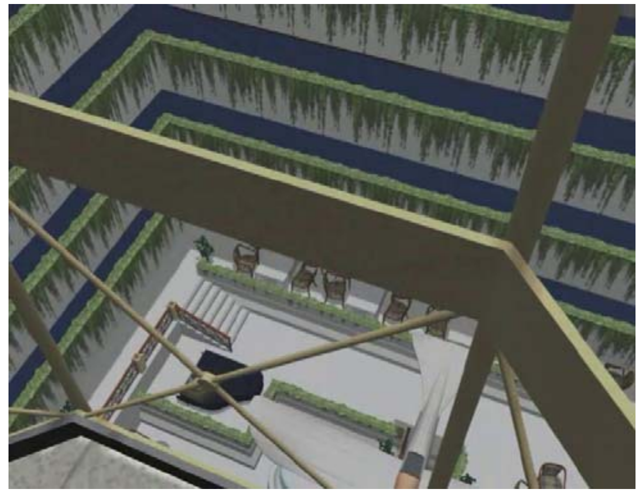

Fig. 2. View from the glass elevator.

A. VEs for Phobia treatment and rehabilitation

Phobia treatment: Our team from the University of Pannonia and SOTE (Semmelweis Medical University in Budapest) aimed to develop a VE to be used in treating phobias. Obviously treating every phobia is beyond our power, we focused only on agoraphobia (fear of wide, open spaces), acrophobia (fear of height) and specific phobia (fear of travelling). We are proud to be the first in Hungary to investigate such problems.

The first environment to be created was an ordinary balcony of a two-storey house with a large tiled floor and a surrounding low fence [58]. Later it was accompanied by a second program: an external and a similar internal glass elevator environment [58]. To create these, video recordings were taken in a hotel in Budapest and these provided the model for the elevator. [59, 60].

For the phobia of travelling the treating environment imitates the underground railway in Budapest. (Fig. 3 and Fig. 4) [61].

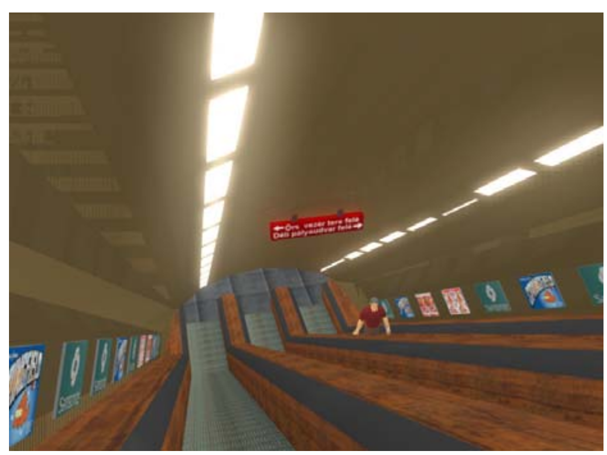

Fig. 3. The escalator. See Color Plate 19

The method was the same: a initial video recording provided the information for the later modelling phase using Maya. We developed a VE for claustrophobia too: a closed lift and a room, where the wall could also be moved.

Fig. 4. The underground waiting hall. See Color Plate 20

The evaluation of our VE-s was carried out with the help of the psychological institute of SOTE and student volunteers suffering from mild phobias. The clinical test with the patients who suffered from severe, complex phobias began in the second half of 2005.

Fig. 5. The virtual shopping.

Another strand of our work is the education of autistic children. For this purpose we developed virtual shopping software. (Fig. 5) [62]. This VE was tested in a special school for children with learning difficulties in Veszprém (Hungary). The application is designed to be an effective supplementary element in the teaching process, but it can be used even at home - with the help of someone to monitor - as a playful way of learning. Based on the advice of teachers working with autistic children, the software uses speech and visual support as guidance for users, with the aim of improving verbal comprehension and communication.

We have also looked at the treatment of problems arising (usually) from having suffered from a stroke [65]. Our environment, the virtual home, was prepared in cooperation with the National Centre of Cerebrovascular Diseases, Budapest for aphasic patients. The aim of our work here was to teach everyday words to stroke patients [63]. The idea is based on earlier 2D multimedia software [64].

For aphasic patients the fundamental environment of cognitive treatment is a common family house with its equipment. This environment differs from it only in the number of the objects it contains: it is very high. The patient's basic task is to name more and more objects.

Fig. 6. The living room corner.

These software were developed for adult patients, but an additional usability test was carried out in a special school for children with learning difficulties. The results are the same as in the adult group so these VEs can also be useful in special education.

B. Adjustable Virtual Classroom (AVC) for fear of public speaking

We developed an Adjustable Virtual Classroom (AVC) to practice public speaking. The AVC virtual environment has two components [66]:

- The "Editor": this is the tool for the user (the teacher or parents) to edit the settings of the AVC
- The "Viewer": displays the AVC modified with the Editor.

The user can start the VE from the Start library or by using a special icon on the desktop.

The children are using this VE in an immersive way with a head mounted display (HMD). Questions to be answered appear on the blackboard, each accompanied by a picture. The user's oral answer can be responded to by the teacher, who monitors and controls the virtual class by making an avatar (a virtual child or the virtual teacher) perform an action in the virtual class. There are other avatars in the virtual class. These ones are controlled by the software randomly. This AVC is expandable and adjustable in an easy way via the Editor. The user (the teacher or the parents) is able to construct old exercises and create new ones. The user can even create a new VE: to make a new class you can import a new model, avatars, texture and sounds. The editor software is able to put pictures of real faces onto the avatar's face.

C. Developing the Adjustable Virtual Class (AVC)

The avatars were made by Poser 6, the models and the animations were developed by Maya 6.5. The texture plans of the virtual models were modified by UVMapper Classic. The models were transformed into DirectX format by Panda DirectX Exporter and 3ds Max 7.0. The textures were constructed by Adobe Photoshop CS2. The Editor was made by Visual C++ 6.0 programming language using MFC (Microsoft Foundation Classes). Using MFC it is easy to construct dialog windows. The data of avatars and classes and the exercises are stored with the help of XML (Extensible Markup Language). The interactive game engine was written in the Visual C++ 6.0 programming language using DirectX 9.0 API-t (Application Programming Interface).

Fig. 7. The virtual class. See Color Plate 21

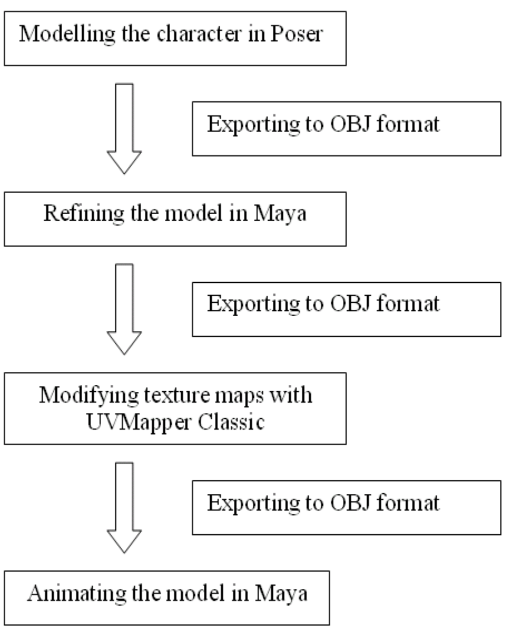

Fig. 8. Process of modelling avatars

One possible virtual classroom is shown in Fig. 7. The process of modelling avatars is shown in Fig. 8. We developed five animations for every avatar, from which the teacher can select or the game engine plays one randomly.

After modelling the objects they have to be transformed into DirectX format to fulfil the requirements of the game engine. Unfortunately the import plug-in for Maya is working incorrectly so we have to use other software: the Panda DirectX Exporter plug-in, which had been made for 3ds Max and was suitable for our task. Therefore the process of modelling started in Maya, where the primary model was created, then this was converted into FBX format (a standard format compatible with all important 3D software), and lastly opened in 3ds Max and transformed into X format. The export plug-in allows the possibility of changing the right-hand coordinate models into left-hand coordinates, because DirectX uses the latter. The export process is shown in Fig. 9. The models in X format are saved into a text file so that the files for the textures and the animations of the avatar share a common path.

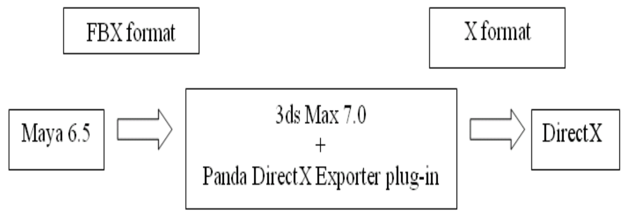

Fig. 9. Transform processing of the models

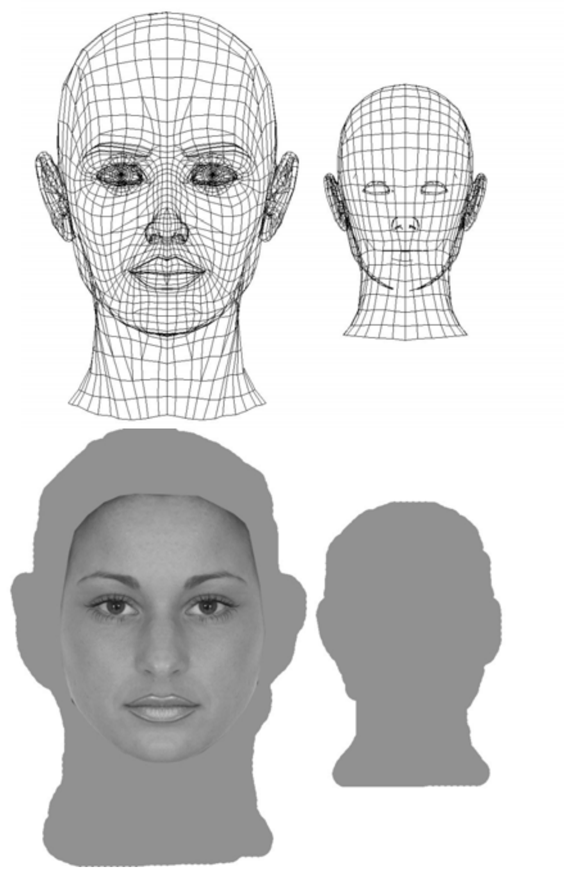

Fig. 10. The texture mapping of the teacher head and the texture with the face picture.

Nearly all of the textures were based on original photos of real classes, children and teachers and the slight modifications needed were carried out in Adobe Photoshop. Sometimes the contrast of the pictures had to be modified. We painted the texture of the head and body that had been made by the UVM -apper Classic and saved it into JPEG format. After this we created the texture of the hair. In modelling the avatar's face, we used original photos. The process needed three layers: the background layer for the loaded face-texture, the top layer for the face copied from the whole texture, and an intermediate one for the creation of a transition between the colour of the face and of the hair.

The library structure where the files of the AVC are stored in a systematic form is shown in Fig. 12.

Fig. 11. |The final version of the virtual teacher.

D. Using the AVC

The necessary hardware configuration:

- IBM PC compatible computer
- 1GHz or larger processor
- 256 MB RAM
- 50 MB free space on hard disk
- DirectX 8.0 compatible video card with 128MB memory
- DirectX compatible soundcard
- mouse

The necessary software configuration:

- Microsoft Windows 98 or Microsoft Windows 2000 or Microsoft Windows XP operation system
- DirectX 9.0 or fresher

Installation of the AVC: If the software does not start automatically the user can start the installation by running the Setup.exe file.

The dialog windows are available from the main menu (Fig. 15).

The language and the parameters of the "Editor" software can be set by the "Options" window (Fig. 16).

The avatars (virtual students and the virtual teacher) can be set by the "People" dialog window (Fig. 17).

A model, clothes, face and hair have to be chosen for every avatar, which can be done by clicking on the  button. If the user has not chosen one of these, the program sends a message before the user wants to save his or her settings and it is impossible to save without having selected these settings. The user can see his or her settings by clicking the "Show" button. It is also possible to link a WAV format sound file to the avatar. It can be heard by clicking the "Play" button.

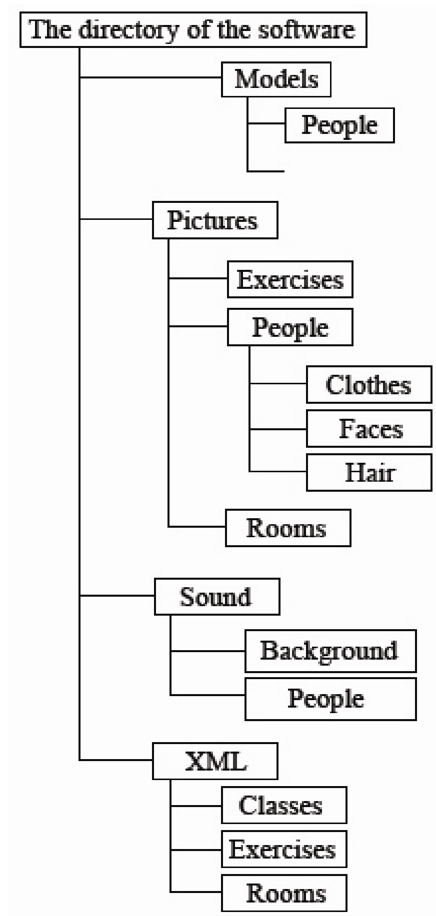

Fig. 12. The directory structure of the AVC software

Fig. 13: Pupils in the class. See Color Plate 22

Fig. 14. The tasks on the blackboard. See Color Plate 23

Fig. 15. The main menu

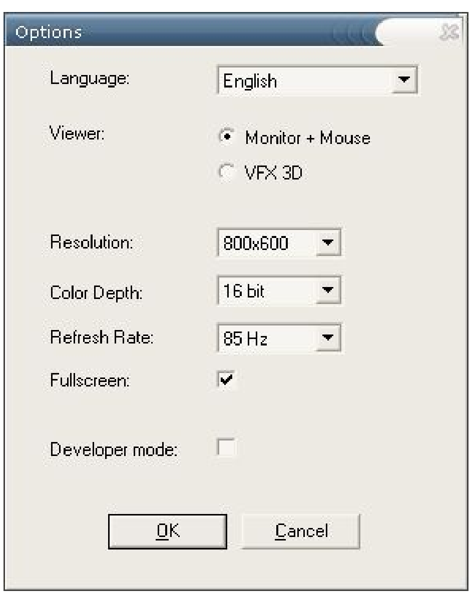

Fig. 16. The options window

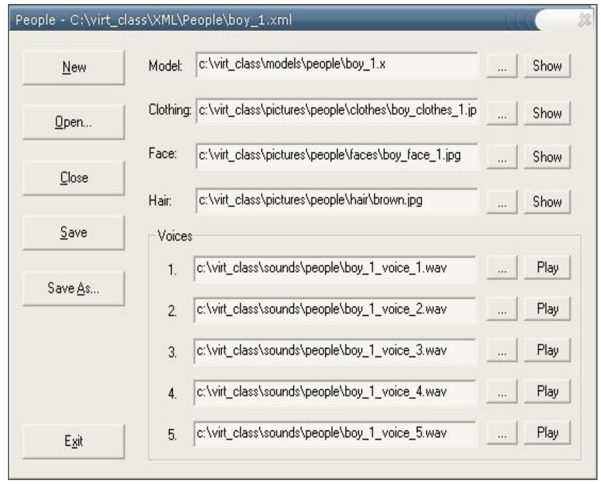

Fig. 17. Settings the data of the avatars

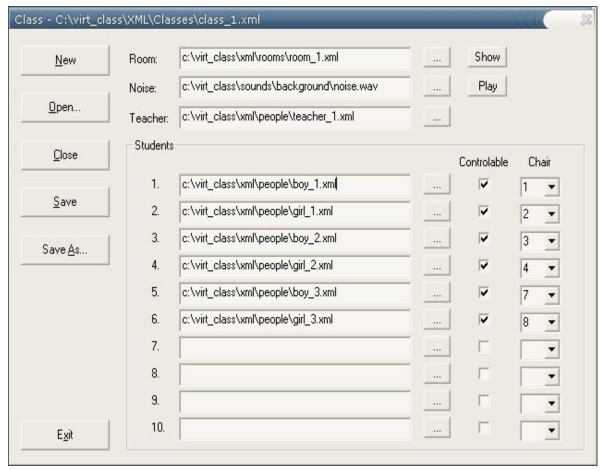

Fig. 18. Setting up the school room community

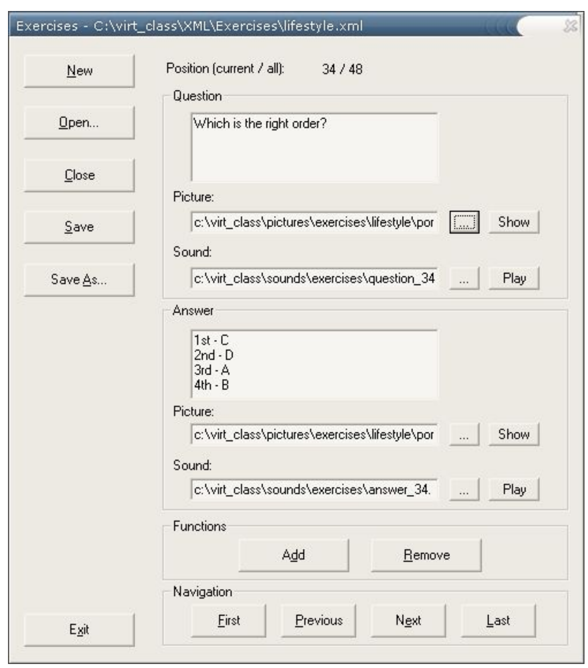

Fig. 19. Setting the exercises

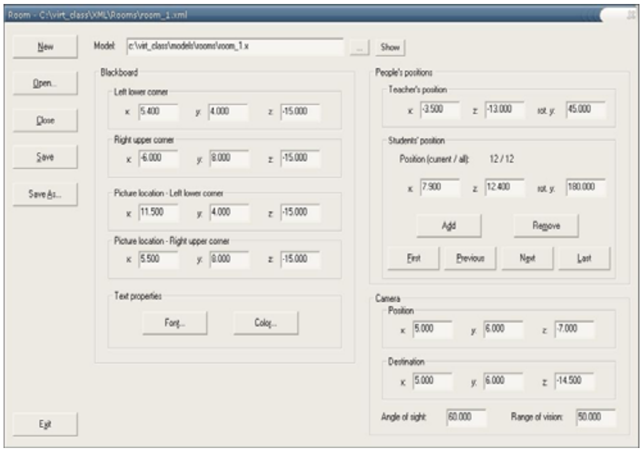

Fig. 20. Setting the room

The school room community can be set in the “Class” window (Fig. 18).

Every class has to have the same path shared with that of the room setting’s file. Here the user can see the floorplan, it contains the number of chairs and they can also choose the background noise too.

The position of the pupils can be modified in the “Class” window too. Here the user can set the actions of a pupil as either controllable or random.

The exercises can be set in the “Exercises” dialog window (Fig. 19). Adding a new task to the exercises menu is possible by clicking the “Add” button after typing the question and answer into the dialog window and filling out the path boxes of the picture and sound of the new task. The maximum length of a question is 200 characters.

The user has to choose from the models and select a room (Fig. 20).

The position and the coordinate of the blackboard must be given too, because the question and answer position and their pictures depend on it. After this, the user has to fill in the position of the question’s picture too. The texts on the blackboard can be set by the “Font” and “Colour” button. The positions of the teacher and the pupils must also be given here. The order of the pupils is important, because this sequence determines the number of each seat in the “Class” dialog window. The position and direction of the camera can be set here too.

The task of the “Viewer” software is to display the virtual classroom whose settings were determined earlier in the “Editor”. There are a lot of shortcuts for the user, for example:

- F1 – F10: choosing a controllable pupil,
- F12: choosing the teacher,
- Alphanumeric 1 – 5: choosing activity (i.e. an animation) for the formerly chosen pupil or the teacher,
- Numeric “–”: “hiding” a task
- Numeric “+”: having a task and its picture shown,
- Left arrow: showing the previous task,
- Right arrow: showing the next task,
- Down arrow: choosing a task randomly,
- Insert: opening a new task queue,
- Home: setting the camera to its basic position,
- Delete: turning on/off the background noise, Alt and X: quitting.

The “Editor” software function buttons are:

- W: moving the camera along the line of site of the camera,
- S: moving the camera to the opposite direction of the view of the camera,
- A: moving the camera to the left side,
- D: moving the camera to the right side, (If pressed together with the left shift, the rate of camera movement is reduced)

Q: saving the actual position of the camera into the positions. Dat. file.

The AVC can be removing from the computer by “Removing AVC” in the library of the software.

E. Usability and pedagogical testing of the AVC

The usability test of the AVC was carried out in Flora Kozmutza Ground School Skill-Developing Special School and College in Veszprem. This institution is attended by intellectual disabilities from the period of nursery school to the years when they prepare for a vocation. The vocational part of the school specialises in weaving. This is the profession taught to the oldest pupils as well as skills for independent living.

The self-development of the students is hampered by their chronic neurological impairment, and its negative consequences on both body and soul. The variation both within and between pupils requires a special, individually adjusted program of education for each child. However, the negative effect of innate problems might be compounded by social ones, for example the lack of stimuli in their environment. This can have implications for their sense of self and identity.

The subject group contained 64 pupil from the institution with an average level of disability and involved some who are likely never to be able to learn to read. In addition they had never been taught computer science and had spent only a negligible amount of time in front of a computer before. They used a HMD, completely new to them, when exploring the VE.

The test involved several subtasks of the VE, and the results are listed according to the task tested :

1) Development of attention

- The HMD and the VE definitely gained the students’ attention due to their newness and the fact that the students’ own classroom was displayed (Fig. 21).
- The ability to explore the VE and to change the field of vision to observe its residents and tasks through simple head motions was very effective in keeping the students’ attention. Every student experiencing the VE remained involved in the task-solving for the duration of the whole test.
- Considering the children’s above-mentioned problems, it is obvious that they are more likely to be vulnerable to distracters than average children. They even have problems fixing their gaze and moving their eyes from left to right. However, during the test the HMD helped them to deal with these problems.

2) Task-interpretation

- In the interpretation of a given task the visual fixation on the site in the VE helped the student to concentrate only on the task. (After the primary tests, on the advice of the teachers we amended the software to include this ability)
- The pictures were shown in good detail and were easy to understand.
- Currently the task exists only in written form so it had to be read aloud for students who were unable to read. As a future development, the user will be able to select an auditory version of the questions

3) Task-solving

- The main concern is that the student plays an active role and becomes as independent as possible. For this reason the trainees suggested using the mouse for selecting the right answer in the VE and providing immediate feedback on whether the answer was correct. This could be an audio, or visual element, or even a change in the colour of the picture. In this way the VE would be more usable for a non-speaking pupil.
- Using the final version of the VE, the students were active and cooperative in solving the task.

4) Feedback

- After solving a task, feedback is obviously needed and this is provided by the teacher in the AVC with speech and gestures. This was so interesting for the pupils that they not only expected but were looking forward to it when doing a task in the VE.
- A suggested improvement would be the ability to return to a task to solve together if the wrong answer was given by the student.
- Another suggestion aimed at reducing the delay before the arrival of feedback was that it could be generated automatically instead of having the real teacher do it.

IV. FUTURE DIRECTIONS

Learning is not limited to school, many study at home or in other settings in the community. The achievements of information and communication technology have made this kind of distributed learning possible. Networks and e-mail will allow pupils to work at home as effectively as in schools. This method of sharing information is obvious, but the need for feedback on the remote students' performance has implications including the teacher's availability, school management, school structure, parental involvement, planning and technical support [67]. By utilising such facilitates effectively, not only is learning made more pleasant but students with disability can also learn in their own time and place and at their own pace, in a more encouraging environment and in a way that suits them. This is the challenge to education: to effectively manage and utilise the potential of pervasive computing [68].

According to surveys 37% of children of the age of five are seriously tongue-tied, they tend to interchange phonemes. Experts state unanimously that this childhood speech defect can be treated but also its neglect can lead to severe learning disorders. There are many possible causes of childhood speech defects, but specific causes have not been identified yet. One suggested cause has been watching too many synchronised films with obviously inaccurate lip movements, which prohibits the connection of phonemes to proper lip formations. A more important cause is likely to be the decreasing amount of parental-children conversation, verbal communication is decreasing and often lack of eye-contact means that the child does not pay attention to parental lip movements [69].

In treating this problem, the authors' future plan is to develop avatars which follow the rules of pronunciation and articulating properly. Obviously the required 3D animations differ from language to language, which means there will be problems when implementing the system for different languages.

Augmenting the VR programs with devices such as data gloves is still expensive, but with the evolution of the VR game industry more and more new equipment is appearing in the market and is hopefully becoming cheaper. In this case the "old" but usable PC-s and game hardware could be used at home or in the clinic or schools for rehabilitation of disabled children. VR researchers are investigating the possibility of delivering VE over the Internet. Eventually it will be possible to offer VR services to disabled children under the supervision of special teachers, doctors or therapists in their homes. In this case the children and the therapists or teachers could go into the same VE at the same time, or hopefully in the near future more children could work collaboratively with their teachers in the same VE at the same time.

V. CONCLUSION

Two major questions for the discipline are: What are the research challenges that informatics faces today? How can the discipline be strengthened and positioned to maximize its success in addressing those challenges? Progress toward research challenges formulated more than ten years ago has been changed. While many new technologies have become available for research, and education, many fundamental problems remain to be addressed by informatics research. We hope that the number of investigations conducted in the field of VR for special needs education will grow. Computer graphics are better now and the 3D rendering techniques are becoming more mature, thus contributing to the reality of the simulated environments.

The review of current VR applications shows that VR can be considered a useful tool for education and rehabilitation. We hope VR will be a new and useful tool for distance learning, distributed training and e-therapy.

However there are also some critical questions. What is the situation with the youngest children? Is VR really dangerous for them? Where is the limit to the use of VR? Are there any ethical standards? These questions are still open. We can only hope that the scientists and users will find the optimal use of this new technology and will not use it for virtual 'killings' as in many games now on the market.

Our opinion of the high usability of HMD and VE was supported by the trainees of Flora Kozmutza School. They can be used for helping individual improvement in general, but can also help speech therapy and even the education of such special cases as autistic children. And, of course, it has proved its value in the treatment of ADHD children.

VE is the ultimate ostensive device, which even seems to reach the level of reality. It greatly enhances skill-development and also provides a way to play.

Fig. 21. Exploring the VE

Fig. 22. Joyful experience

As it was stated in the preceding section, HMD and VE are appropriate for the development of visual fixation and the left-right motion of the eyes, which are fundamental in learning to read and also in speech interpretation and communication in general. In addition to its influence on skills it can be a source of joy and motivation for success (Fig. 22). Considering the features which have been described, it could greatly help students getting on in later life, which is the most important feature above all.

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Cecilia Sik Lanyi is an associate professor of University of Pannonia (former University of Veszprém), Hungary. She got his Ph.D degree in computer science from University of Veszprém, Hungary in 2000. Dr. Sik Lanyi is a member of the John von Neumann Computer Society in Hungary. She is the Secretary of the Applied Light and Colour Working Group of the Veszprém Branch of the Hungarian Academy of Sciences (MTA VEAB). She got the “Master teacher” award from the Hungarian Ministry of Education in 2001.

Zoltan Geiszt is a software engineer at Knorr Bremse Fékrendszerek Kft., Hungary. He got his Diploma (M. S. equivalent) from University of Veszprém, Veszprém, Hungary (Information Technology), 2005. From 2005-2006, he is a PhD candidate at the Department of Image Processing and Neurocomputing, Information Science and Technology PhD School, University of Pannonia, Hungary.

Peter Karolyi is a software engineer at Continental Teves Magyarország Kft., Veszprém, Hungary. He got his Diploma (M. S. equivalent) from University of Veszprém, Veszprém, Hungary (Information Technology), 2006.

Adam Tilinger is a PhD candidate at Department of Image Processing and Neurocomputing, Information Science and Technology PhD School, University of Pannonia. He got his Diploma (M. S. equivalent) from University of Veszprém, Veszprém, Hungary (Information Technology), 2003.

Viktor Magyar is a PhD candidate at Department of Image Processing and Neurocomputing, Information Science and Technology PhD School, University of Pannonia. He got his Diploma (M. S. equivalent) from University of Pannonia, Veszprem, Hungary (Information Technology), 2006.