Virtual reality in vocational training of people with learning disabilities

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ABSTRACT

This paper reports a 3-stage investigation of virtual environments (VEs) in vocational training of people with learning disabilities. Stage 1 results showed that active interaction with a VE can give better learning than passive observation and that some of what is learned in a VE can transfer to the real world. Stage 2, a questionnaire survey, identified catering as the most popular choice for a virtual training package. Stage 3, a preliminary evaluation of that package, showed some positive transfer of training to a real kitchen test and provided clear justification for further development of this type of training.

1. INTRODUCTION

It is estimated that 2% of the population of the UK, 1.2 million people, have some degree of learning disability. This figure includes many types and severities of impairment and consequently a wide range of functional disabilities (see Jacobson and Mulick, 1996, for a review). However, even mild to moderate learning disabilities, which account for about 80% of the total, can be profoundly disruptive in terms of the educational, family, social and work lives of those affected. It is clear that for a very large number of people their learning disability is the cause of a significant level of social exclusion. It has long been recognised that one of the most effective ways to combat this problem (i.e. to increase social inclusion among people with learning disabilities) is to increase their employment opportunities. One of the keys to this, in turn, is improved vocational training.

In the UK, local authorities, private sector organisations and charities all contribute to vocational training of people with learning disabilities. Trainers employ a variety of training methods but, it is widely agreed, training is always extremely staff intensive. There is a pressing need for aids that can improve the efficiency of the training process. The potential of Virtual Reality (VR) in this regard is clear and has already been noted by others (Cromby, Standen and Brown, 1996). That VR based training can be effective is no longer in dispute (Siedel and Chatelier, 1997) and many of the characteristics of this training medium (rigorous control, instant feedback, precise performance measurement, reduced hazards, etc.) have an obvious relevance to training people with learning disabilities. VR based training packages for people with learning disabilities already exist. For example, Mowafy and Pollack (1995) described a “Train to Travel” package designed to train people with learning disabilities to use public transport. Brown and his colleagues (Brown, Neale, Cobb and Reynolds, 1999) for some years have been developing a virtual city, incorporating streets, shops and residential accommodation, for training a range of life skills. Pugnetti, Barbieri, Attree et al. (1999) have described the development of a virtual “Factory Trainer” in which people with learning disabilities can be trained to assemble a torch from prepared components, and to carry out simple labelling and packaging tasks.

All those who have reported such projects have also reported encouraging preliminary evaluations. However, such evaluations have been varied in terms of methodology and extent. It is important that the use of VR in training people with learning disabilities be fully and rigorously evaluated. For example, it is important to establish whether skills acquired by people with learning disabilities in virtual training environments transfer to real world environments. It is also important to know whether VR based training confers any advantages over more conventional training methods such as the use of video. Finally, it is important to ensure that both those with learning disabilities and their trainers feel comfortable with and have confidence in the use of this type of technology.

This paper describes our progress so far with a project commissioned by MENCAP, the UK’s leading charity concerned with learning disability, to assess the feasibility of using VR in vocational training of people with learning disabilities. The project is divided into three phases.

2. LABORATORY BASED INVESTIGATION OF VIRTUAL TRAINING OF PEOPLE WITH LEARNING DISABILITIES

Two preliminary studies were performed to investigate whether it would be feasible to train people with learning disabilities in virtual environments and whether they would be likely to benefit from such training. The first study investigated whether people with learning difficulties were able to perform a task in a virtual environment, whether they enjoyed the experience, and whether they benefited from active participation compared to passive observation.

2.1. Preliminary Study 1 - Method

Participants were 30 students with learning disabilities, 16 male and 14 female, age range 17 to 46. They were all undertaking vocational training courses, 24 at Lufton Manor College, Somerset and 6 at Red House College, Colchester.

The virtual environment was constructed using Superscape VRT software, run on a desktop computer and explored using an analogue joystick. It was based on that used by Brooks et al. (1999) and depicted four inter-connected rooms in a bungalow - a bedroom, a music room, a lounge and a kitchen. In the rooms were 20 items, e.g. a piano, a bottle of wine.

Participants were allocated either to an active or a passive experimental group. Active participants were first shown how to use the joystick and were then required to find a route through the rooms in the bungalow and to search for a toy car. If a participant had trouble manipulating the joystick, a minimum level of help was provided. Passive participants were required to watch a replay of the progress of the previous active participant and to search for the toy car. The toy car was in the kitchen, the last room they entered.

Immediately they had finished the task, all participants were asked if they could remember how many rooms there had been in the virtual bungalow. They then performed a spatial recognition test in which they were required to select room shapes, exit walls, and the positions of exit and entry doorways according to their recollections of the bungalow. Their selections were assembled into 2-D plans of the spatial layout of the bungalow. There followed an object recognition test in which participants were randomly presented with colour photographs of 20 items from the bungalow and 20 distractors and were required to respond "*Yes*" or "*No*" depending on whether or not they remembered the item had been in the bungalow. After the object recognition test, the passive participants were given the opportunity to explore the bungalow themselves and 12 took advantage of this offer.

Finally, all the participants were asked the following questions: "Did you enjoy taking part in the study? Would you like to use virtual environments during your college training? Do you often use computers? Have you used a joystick before?".

In addition, all the active participants and those passive participants who had explored the VE were asked: "Were you able to use the joystick to explore the bungalow?".

All participants were then thanked for their participation and the purpose of the study was explained to them.

2.2. Preliminary Study 1 - Results

In all the statistical analyses reported in this study, the alpha level was set at 0.05. Participants in the active and passive groups did not differ in terms of age [$t(28) = 0.59$, $p = 0.56$]. Twenty-nine of the 30 participants reported that they enjoyed taking part in the study and 24 reported that they would like to use virtual environments during their college training. Active and passive participants did not appear to differ in their familiarity with computers with 12 active participants and 13 passive participants reporting that they used computers often. Neither did they differ in their prior use of a joystick with 8 active participants and 7 passive participants reporting that they had used a joystick before. With regard to using the joystick in the present study, 13 of the 15 active participants reported that they were able to use the joystick compared to 11 of the 12 passive participants.

Performance on the spatial layout recognition test was scored on a predetermined criterion, which allocated a maximum of 4 marks according to number and shapes of rooms, entry doorway positions, exit walls and exit doorway positions that participants correctly identified. This gave a total maximum score of 20 for the whole test. Object recognition was also scored out of a possible 20 points. To correct for guessing, incorrectly recognised lure objects were subtracted from correctly recognised target objects (Baddeley, et al., 1990).

Table 1. *The effects of active and passive participation in a virtual environment on subsequent spatial and object recognition.*

	Active Mean	SD	Passive Mean	SD
Spatial Recognition Test	11.07	2.66	8.13	2.53
Object Recognition Test	10.27	2.15	10.73	3.96

Table 1 shows the results of the spatial and object recognition tests. Inspection of this suggests that active participants scored higher than passive in the spatial layout recognition test but that active and passive participants' scores were similar in the object recognition test.

A 2 x 2 analysis of variance (ANOVA), with one between subjects factor, Participation (active vs. passive), and one within subjects factor, Test (spatial recognition vs. object recognition), was performed. Neither the effect of Participation [$F(1,28) = 2.15$, $p = 0.15$] nor the effect of Test [$F(1,28) = 1.94$, $p = 0.17$] was significant but there was a significant interaction between Participation and Test [$F(1,28) = 6.94$, $p = 0.01$]. An investigation of this interaction showed significant differences in the spatial recognition test between active and passive participants with the active participants scoring higher [$t(28) = 3.10$, $p = 0.004$. In the object recognition test, there was no significant difference between the active and passive participants [$t(28) = 0.40$, $p = 0.69$].

The above results therefore showed that active participation enhanced recognition of the spatial layout of the virtual bungalow compared to passive observation of the active participants' progress. Conversely, active participation did not enhance recognition of virtual objects compared to passive observation.

The second study investigated whether virtual training of a simple task would transfer to improved real task performance.

2.3. Preliminary Study 2 - Method

Sixty-five students with learning disabilities, 34 male and 31 female, age range 16-46, volunteered to participate in the study. They were all undertaking vocational training courses, 38 at Lufton Manor College, Somerset and 27 at Red House College, Colchester.

Real and virtual versions of a steadiness tester (Rose et al., 2000) were used in the study. The real steadiness tester consisted of a curved wire, 500 mm long and 2 mm wide, suspended between two 200 mm high vertical supports. Encircling the wire was an 80 mm diameter metal ring attached to a 40 mm long metal rod. At the end of the rod was a wooden handle. The participant was required to hold the handle in her/his preferred hand and move the ring along the wire from one vertical support to the other and back again, trying not to allow the ring to touch the wire. If the ring did touch the wire, a buzzer sounded and an error was recorded on an electrical counter.

The virtual version of the task was created using Superscape VRT software. A computer generated 3D simulation of the steadiness tester comprising the wire, the supports and a metal ring, was run on a desktop computer. 3D Movement of the ring along the wire was controlled using a Polhemus FastTrak sensor and receiver. The sensor was attached to a wooden handle that was identical to the handle of the real steadiness tester. As with the real steadiness tester task, the participant was required to hold the handle in her/his preferred hand and move the ring along the wire from one vertical support to the other and back again, trying not to allow the ring to touch the wire. If the ring touched the wire, a buzzer sounded.

Participants were tested individually. They sat in front of the real steadiness tester whilst the task was explained to them. They then performed one test trial on the real steadiness tester during which their performance and errors were noted. In the opinion of the experimenter, the performance of 20 of the volunteer participants was not considered to be of a sufficiently high standard to benefit from further training. These volunteers were thanked for their participation in the study and given the opportunity to perform the virtual steadiness task if they wished. The remaining 45 participants were randomly allocated to three groups - a real practice group, a virtual practice group and a no practice group.

Participants in the real practice group were then instructed to perform five practice trials on the real steadiness tester followed by a final test trial. Their performance was self-paced but they were encouraged to rest between the practice trials and before the final test trial. Participants in the virtual practice group sat in front of the virtual steadiness tester whilst the task was explained to them. They were instructed to perform five practice trials on the virtual steadiness tester followed by a final test trial on the real steadiness tester. Their performance was also self-paced and they were encouraged to rest between and after the practice trials. Participants in the no practice group chatted to the experimenter for approximately 10 minutes. This time period was based upon pilot data that showed that 10 minutes was the average time taken by participants to complete the real or virtual practice trials. They were then instructed to perform a second test trial on the real steadiness tester.

At the end of the study, participants were thanked for taking part and the purpose of the study was explained to them. Participants in the real practice and no practice groups were also given the opportunity to perform the virtual steadiness tester task and approximately half of them took advantage of this offer.

2.4. Preliminary Study 2 - Results

In all the statistical analyses reported in this study, the alpha level was set at 0.05. Table 2 shows participants' errors as a function of test and practice.

Table 2. *Participants' errors as a function of Test and Practice.*

	First Test		Final Test		% Improvement	
	Mean	SD	Mean	SD	Mean	SD
Real Practice	68.53	22.47	42.40	18.25	36.10	20.65
Virtual Practice	66.27	17.09	50.67	17.33	23.13	17.26
No Practice	67.53	30.39	60.20	21.80	6.58	18.65

It appears from Table 2 that improvement across trials in the real and virtual practice conditions was higher than improvement in the no practice condition. In support of this interpretation of the data, an analysis of variance (ANOVA) performed on percentage improvement scores with one between-subjects factor, Practice (real vs. virtual vs. no practice), showed a significant effect of Practice [$F(2,42) = 9.19$, $p < 0.001$]. An investigation of this significant effect showed a significant difference between real and no practice [$t(28) = 4.11$, $p < 0.001$] and between virtual and no practice [$t(28) = 2.54$, $p = 0.02$] with a marginally significant difference between real and virtual practice [$t(28) = 1.87$, $p = 0.07$]. It therefore appears that real and virtual practice both resulted in better real task performance than no practice but that real practice was marginally more beneficial than virtual practice on subsequent real task performance.

3. QUESTIONNAIRE SURVEY AND SMALL GROUP FOLLOW-UP OF LEARNING DISABILITY TRAINERS TO INVESTIGATE THEIR VIEWS OF USING VR WITHIN VOCATIONAL TRAINING

Questionnaires were distributed to trainers at MENCAP's three colleges and to MENCAP Pathway Employment trainers throughout the country. Forty-nine completed questionnaires were received. The reported number of people with learning disabilities trained each year ranged from 3 - 60, depending whether trainers worked alone or in a college setting. Trainers were presented with a comprehensive series of questions relating to their trainees and their training methods followed by a number of possible responses and space for additional responses. They were required to tick any responses that applied to them and to rank their responses in order of importance. For example, to the question "How are your trainees referred to you?", the most ticked and most highly rated response was "by the Social Services".

The training most frequently undertaken by these trainers was Vocation Specific, followed by Health and Safety, Personal Development and Social Skills. With regard to vocation specific training, the most frequently cited vocation was Catering, followed by Horticulture, Factory Work and Retail. The most frequent vocational qualification undertaken by people with learning disabilities was the National Vocational Qualification (NVQ) Level 1 with 67 students per annum taking Catering and 43 taking Horticulture.

Training methods included demonstration, systematic instruction and task analysis and these were all considered to be time consuming aspects of the training process. Another time-consuming aspect was the preparation of suitable training material. The most common training aids were workbooks and videotapes.

The biggest barriers to learning were judged to be lack of confidence, memory difficulties and attention problems.

On the basis of the responses in these questionnaires, it was decided that a virtual kitchen with tasks based on NVQ Level 1 Catering would be the most useful virtual environment with which to assess the feasibility of using VR in vocational training of people with learning disabilities. The virtual kitchen was modelled on a real kitchen used by NVQ Level 1 Catering students at Red House, Colchester.

The responses of eight trainers to the tasks contained in the virtual kitchen were sought on a follow-up questionnaire. There were three main suggestions that emerged from these questionnaires. One was to include a video facility depicting real task performance that could be operated by students if they wished. Another was that the voiceover should be slower with a repeat facility. The third was that there should be the facility to break down tasks into smaller steps that could be gradually increased to encompass the whole task. These suggestions were all incorporated into the final version of the virtual kitchen.

4. A PRELIMINARY EVALUATION OF A VR BASED PROGRAMME FOR CATERING TRAINING FOR PEOPLE WITH LEARNING DISABILITIES LEADING TO THE NATIONAL VOCATIONAL QUALIFICATION AT LEVEL 1

Real task performance before and after virtual kitchen training, real kitchen training, workbook training and no training were compared in this preliminary evaluation.

4.1. Method

Twelve students with learning disabilities, 6 male and 6 female, age range 15 - 33, volunteered to participate in the study. They were all undertaking catering courses, six at Harlow College, Essex, and six at Pinewood School, Ware.

The virtual kitchen was constructed using Superscape VRT software, run on a desktop computer, explored using the keyboard direction arrows, and manipulated using a mouse. There were four food preparation and cooking tasks - meat (pork chops), fish (salmon steaks), vegetables (carrots), and fruit (apples). A further task involved recognising potential hazards that were distributed around the virtual kitchen. Twelve hazards were presented in four sets of three.

All participants were tested and trained individually. They were first pre-tested on all four food preparation tasks in the real kitchen. For each task they were marked out of 20 points on 10 items, e.g. washing hands in the correct sink, choosing the correctly coloured chopping board. They were also asked to identify any potential hazards they could find in the real kitchen and their performance was marked. (Twelve potential hazards were distributed around the kitchen, e.g. a toaster with a frayed flex, a puddle on the floor).

They were then trained, for approximately 15 minutes each, on three of the food preparation tasks, one in the real kitchen, one in the virtual kitchen, and one in specially designed workbooks. They were also trained to identify three of the hazards in the real kitchen, three in the virtual kitchen, and three in their workbooks. They did not receive any training on one food preparation task and three hazards. The tasks and hazards were fully counterbalanced across participants so that equal numbers of participants were trained on each of the tasks and hazards in the different mediums. Participants all received three training sessions over a two or three week period. They were then re-tested in the real kitchen on all four food preparation tasks and all the hazards using the same criteria as had been used previously.

4.2.Results

In all the statistical analyses reported in this study, the alpha level was set at 0.05. Scores in the food preparation tasks as a function of type of training are shown in Table 3.

Table 3. *Pre-test, post-test and improvement scores in the food preparation tasks as a function of type of training.*

	Real Training		Virtual Training		Workbook Training		No Training	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-Test	6.00	2.83	6.41	2.39	5.91	2.11	5.83	2.29
Post-Test	12.00	2.26	14.75	4.07	9.58	2.39	8.67	3.26
Improvement	6.00	3.36	8.33	4.89	3.67	2.87	2.83	3.59

It appears from Table 3 that improvement from pre to post-test in the real and virtual training conditions was higher than improvement in the workbook and no training conditions. An ANOVA performed on improvement scores (calculated by subtracting pre-test scores from post-test scores) showed a significant difference between the four training conditions [F(3,33) = 7.03, p = 0.001]. Subsequent analyses showed significant differences between virtual and workbook training [F(1,11) = 7.71, p = 0.018] and between virtual and no training [F(1,11) = 10.27, p = 0.008] with virtual training showing more improvement in each case. There was no significant difference between real training and virtual training [F(1,11) = 2.64, p = 0.13].

Scores in the hazard recognition task as a function of type of training are shown in Table 4.

Table 4. *Pre-test, post-test and improvement scores in the hazard recognition task as a function of type of training.*

	Real Training		Virtual Training		Workbook Training		No Training	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-Test	1.33	0.49	1.00	0.85	1.33	0.78	1.58	0.90
Post-Test	2.67	0.49	2.42	0.90	2.33	0.78	2.00	0.85
Improvement	1.33	0.65	1.42	1.08	1.00	0.95	0.42	1.17

An ANOVA performed on improvement scores showed a significant difference between the three training conditions [F(3,33) = 3.32, p = 0.32]. Subsequent analyses showed a significant difference between virtual and no training [F(1,11) = 16.5, p = 0.002] but no significant difference between virtual and workbook training [F(1,11) = 1.36, p = 0.27] nor between real and virtual training [F(1,11) = 0.05, p = 0.82].

It therefore appears that participants benefited more from virtual training than from workbook training in the food preparation tasks but this benefit was not apparent in the hazard recognition task.

5. DISCUSSION

The laboratory based part of the present research programme provides empirical evidence that, for people with learning disabilities, active interactions with an environment can produce better learning of at least some types of information than passive observations of that environment. This suggests that the use of virtual representations of training situations should be a valuable addition to the conventional use of video recordings, especially as the majority of participants reported that they enjoyed interacting with the virtual environment. The laboratory based studies also show that what is learned in a virtual environment can transfer to a real world test situation. Whilst these findings have been reported before with regard to other populations (Brooks et al, 1999; Rose et al, 1999; 2000), confirmation of their validity with people with learning disabilities is a crucial step in assessing the feasibility of using VR in vocational training of this group.

When taken out of the laboratory and applied to real world vocational training in catering there is also evidence of significantly better transfer from virtual training to the real task than from the conventional workbook training method. However, on other aspects of the training (hazard spotting) virtual training was no better than work book based training in terms of its contribution to final real world performance. This variation between different aspects of the training requires further investigation. As yet only 12 students have been included in the evaluation of the virtual catering training and a clearer picture of benefit may emerge when this number is increased.

There are also further questions to address. Nowhere in our results is there any evidence that virtual training is actually superior to real training. Its advantage to trainers, therefore, will lie in its potentially being more efficient and, in particular, less demanding of staff time. We intend that this will be further investigated within a more extensive trial of the virtual catering package in a number of training centres.

A further potential advantage of VR in vocational training for people with learning disabilities lies in its adaptability to individual profiles of ability. As noted above the population we are here concerned with includes a wide range of types and severities of learning disability. This necessarily complicates the task of trainers. However, the virtual kitchen, with its comprehensive performance monitoring facility, can be used to assess individual students before training begins and thus allow the trainer to more precisely tailor the training programme to the individual student. A closer examination of this will also form part of the remainder of the present evaluation.

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Effective strategies of tutors teaching adults with learning disabilities to use virtual environments

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ABSTRACT

Nine adults with learning disabilities spent up to twelve sessions with a non-disabled tutor learning to use desktop virtual environments designed to teach independent living skills. Sessions were recorded on videotape and analysed for frequency of tutor behaviours and goals achieved by learners. Before goals could be achieved, the learner had first to master the interaction devices and then learn to navigate around the environment. Preliminary analysis suggests that goal achievement maintains a constant level while instruction about the input devices and specific information about the environment decrease. Behaviours that maintain attention and motivation increase while positive feedback remains constantly high.

1. INTRODUCTION

Following an increase in its role in mainstream education, computer delivered instruction has started to make a contribution to the education of children with learning disabilities (Goldenberg 1979; Dube, Moniz & Gomes 1995; Chen & Bernard-Opitz, 1993). Interactive software encourages active involvement in learning and gives the user the experience of control over the learning process (Pantelidis, 1993). This is especially important for people with learning disabilities who have a tendency to passive behaviour (Sims, 1994). The learner can work at their own pace (Hawkridge and Vincent, 1992). They can make as many mistakes as they like without irritating others and the computer will not tire of the learner attempting the same task over and over again, nor get impatient because they are slow or engrossed in particular details (Salem-Darrow, 1995).

As an example of interactive software, virtual environments have a contribution to make to the education and training of students with learning disabilities (Cromby, Standen and Brown, 1996). Cromby et al (1996) draw attention to three characteristics in addition to those shared with other forms of computer delivered education which make them particularly appropriate for people with learning disabilities. First, virtual environments create the opportunity for people with learning disabilities to learn by making mistakes but without suffering the real humiliating or dangerous consequences of their errors. Secondly, virtual worlds can be manipulated in ways the real world cannot be. A simple world can be constructed within which the task could be performed and as the user becomes more familiar with the task the world can become more complex. Features to which the learner needs to pay attention can be made more prominent (McLellan, 1991).

Thirdly, in virtual environments rules and abstract concepts can be conveyed without the use of language or other symbol systems. Virtual environments have their own "natural semantics" (Bricken, 1991): the qualities of objects can be discovered by direct interaction with them. They can thus be used to facilitate concept attainment through practical activity, by-passing the need for disembedded thinking (Donaldson, 1978) which people with learning disabilities often find difficult to acquire and use.

Initial work suggests that virtual environments are effective in facilitating the acquisition of living skills for example shopping and navigating new environments (Standen, Cromby & Brown, 1997, 1998; Standen and Cromby, 1997) and Makaton sign language (Standen and Low, 1996) by children with severe learning disabilities. With the wider availability of computers in both primary and secondary schools for mainstream and special education (Light, 1997) there is a need to investigate a range of questions about this new aid to learning. However at the same time, there are adults with learning disabilities who may have had little or no computer experience at school but whose continuing educational needs have been recognised by the Tomlinson Report (1997).

Around 20 people in every thousand have mild or moderate learning disabilities and about three or four per thousand have severe learning disabilities. They are unlikely to enter employment when they leave school or to achieve the level of independence expected by the rest of society. Adults with learning disabilities will have the option to attend some form of college or day centre, the role of which is to provide training programmes relating to the development of daily living, social and educational skills. As in special education, VE have a role to play in this. Brown et al (1999) have developed a virtual city for people with learning disabilities to facilitate the learning of skills like catching a bus, road crossing and buying food in a café

Rostron and Sewell (1984) see computers as just "one more useful facility in the general remedial framework that is available" (p9) but advise that they are not there to replace human teachers, just to provide them with additional teaching aids. Computers are highly motivating but Rutkowska and Crook (1987) caution against the naïve belief that unguided interaction can effectively exploit their educational potential (p91). There are two ways that interaction can be guided in this form of learning. The first is through the involvement of a human tutor. The work described above using virtual environments was carried out utilising desk top systems where the public nature of the display allows interactions between the learner and a tutor. A study by Standen & Low (1996) examined the strategies employed by teachers who were encouraging school aged students with severe learning difficulties to use a virtual environment to learn Makaton sign language. They found that teachers contributed significantly less as sessions progressed selectively dropping the more didactic and controlling behaviours in their repertoire.

For both children and adults with learning disabilities it is important to learn with a tutor but staff are responsible for too many students to be able to give one-to-one tuition on a regular basis and when they are able to provide this function need guidance on effective strategies. According to Hawkridge and Vincent (1992) teachers need help and encouragement to build their confidence and skills in using computers and deserve proper training opportunities. Resolution of this situation involves a consideration of the functions of the tutor. One of the primary functions of tutoring according to Wood, Bruner and Ross (1976) is to allow the learner to make progress by initially providing scaffolding, for example by controlling those elements of the task that are initially beyond the beginner's capability. As the beginner becomes more familiar with elements of the task and develops the ability to carry it out independently the tutor intervenes less. Another is to maintain the learner's interest and motivation, marking relevant features of the task and interpreting discrepancies between the learner's productions and correct solutions. As proposed by Slator et al (1999) the first of these functions could be incorporated into the software. This would be either in the form of unintrusive tutoring (giving advice but not preventing actions) or intelligent software tutoring (providing feedback based on the tutoring agent's experience of the task and the learner's behaviour). Such a software tutor would enable a less experienced person, even a peer to carry out the function of maintaining the learner's interest and motivation.

In order to inform the design of the software tutor we set out to investigate what strategies human tutors used when working with adults who were learning to use virtual environments and how effective these strategies were.

2. METHOD

2.1 Participants

So far data are available on 9 people attending a social services adult training centre for people with learning disabilities. They would all be described as having moderate to severe learning disabilities but staff have yet to score them on the AAMR Adaptive Behaviour Scale (Nihira et al 1998).

2.2 Design

Each participant completes up to 12 sessions and changes from baseline and over time are examined

2.3 Virtual environments

The virtual environments shown in Figure 1 have been developed as part of the Virtual City project sponsored by the National Lottery Charities Board. The project consortium consisted of The University of Nottingham, The Shepherd School and The Metropolitan Housing Trust (Brown et al, 1999). All of these environments were displayed on Pentium II with 17" monitor, operated using a standard 3 button mouse or trackball.

2.4 Procedure

Service users who wished to take part spent a session using a 2 dimensional routine to learn how to use the mouse. Once this had been mastered they moved on to the other environments in the same order (road crossing, café, supermarket, factory) only progressing to the next once a defined level of mastery had been achieved. Sessions were scheduled as close as possible to twice a week and lasted approximately 30 minutes. They were recorded on videotape, the camera positioned to view both the learner and the tutor sitting next to them.

Virtual Supermarket

The Virtual Supermarket was based on a real supermarket in Nottingham and aimed to promote basic shopping skills. The Virtual Supermarket is illustrated here and the learning objectives identified for this environment are as follows:

- Creating an icon-based shopping list
- Selecting items from the shelves
- Finding all the items from the shopping list
- Paying for goods at the checkout

Virtual Café

The contents and layout of the virtual café were based upon the University of Nottingham's Art Centre Café. The Virtual Café is illustrated here and the learning objectives identified for this environment are as follows:

- Making choices and decisions – ordering drinks from a list for self and others.
- Social skills when ordering
- Communication with staff and public
- Money handling - paying for drinks
- Appropriate behaviour - table manners, etiquette
- Appropriate dress
- Toilet use in public situation
- Dealing with alcohol - what drinks you can order at what ages, and the affects these drinks may have on you

Virtual Transport

The Virtual Transport system was designed as a way of physically linking the other three VEs. Thus, the user could take the bus from the house to the supermarket, or to the café, etc. The bus route was not modelled on any actual location but the buses themselves were made to resemble Nottingham City buses which the users would be using. The Virtual Transport environment is illustrated here and learning objectives identified for this VE are as follows:

- Select the correct coins for the bus
- Leave the house with enough time to catch the bus
- Cross the road safely
- Catch the correct bus
- Pay the bus driver and collect your ticket
- Get off the bus at the correct stop

Virtual Factory

The Virtual Factory was designed in collaboration with the Health Authority to teach health and safety skills to people with learning disabilities entering sheltered employment. The learning objectives identified for this VE are:

- Selecting correct clothing before entering the factory
- The dangers of entering black and yellow lines
- Storage of chemicals
- Fire safety drills
- Collection of COSSH forms
- Hygiene within the factory

Figure 1. *Virtual Environments.*

3. RESULTS

3.1 Coding of videotapes

The coding system was developed with the help of RB who had previously carried out a pilot study on 9 service users. The system went through 3 different phases before a satisfactory level of repeat reliability (between 75 and 80%) could be established.

Tutor behaviour was coded into 5 categories

- *Specific information* given to learner about achieving a goal and was further categorised as being about the mouse, the joystick or the environment (e.g. "go over to the bar now).
- *Non-specific information* did not provide the help a learner needed to achieve a goal but made the learner aware of possibilities and was similarly categorised as concerning the mouse (e.g. "where are you going to click then?"), the joystick or the environment.
- *Gesture* covered any movement made by the tutor for example pointing to direct attention to the screen or to instruct movement of the arrow on the screen or to direct movement through the environment.
- *Touching* controls included the tutor putting their hand over the learner's or taking over the input device to demonstrate and was further categorised as concerning either the mouse or the joystick.
- *Feedback* could be either positive such as praise or reassurance (e.g. "well done", "that's good") or negative ("no, not like that").

Learner behaviour was categorised in terms of the number of goals they achieved in an environment and could be either positive (finding an item on the shopping list) or negative (stepping into the road before the light has turned to green).

3.2 Analysis

Sessions were divided into 10 second intervals and whether or not a particular behaviour started during this interval gave it a score of 1. Therefore the maximum score for a behaviour for any one session could not be greater than the number of 10 seond intervals in that session. The score was converted to rate per minute to take account of differences in duration of sessions.

3.3 Use of input devices

One of the tasks of the tutor was to assist with mastery of the input devices but specific information about them was always given at a lower rate than about the environment itself. Both touching and specific information about the mouse (see Fig. 1) and the joystick (see Fig. 2) did decrease over repeated sessions. Unsurprisingly there were very low levels of non-specific information throughout.

3.4 Learners' achievement of goals

Environments differed in the number of goals there were to achieve and on the early attempts at each environment not all goals were attempted. Figure 3 shows the rate per minute at which goals were achieved irrespective of which environment the learner was working on. To give context to the activity of the tutor, it appears that learners were achieving goals at a steady rate. However, to give a true picture of achievement, rates need to be adjusted to take account of the total possible number of goals that could be achieved in each particular environment and also whether the learner had just progressed to that environment.

3.5 Tutors' strategies

Although learners' goal achievement was remaining at a steady level, tutors provided less and less specific information as sessions progressed while giving increasingly more non-specific information (see Fig. 4). Negative feedback was always very low while positive feedback remained at a high level. Closer analysis might illustrate whether this was needed to maintain learners' motivation or because it was a default level for the tutor and insensitive to behaviour on the part of the learner.

4. DISCUSSION

Although we had established a method of coding in an earlier study a new scheme had to be adopted for this study because the participants were much more able and verbal. However, this new system retained the distinction between help with input devices and help with negotiating the environment. The amount of help given with the mouse was much lower than that given with the joystick because specific training was given with the mouse prior to starting on the first virtual environment. Similar training with the joystick would have been helpful as well as a user friendly method for determining individual settings for the controls. The distinction between specific and non-specific information follows work on children's learning (Wood et al, 1976) where different levels of control exerted by the tutor were distinguished. Changes over time in the present study suggest that this distinction is worth maintaining. The tutors appear to be following the expected pattern of intervening or controlling less thus allowing more time for the behaviours which maintain the learner's interest and motivation and function to interpret the learner's activity. This distinction might also correspond to that between tasks which can be written into the software tutor (specific information) and those that need the presence of a human tutor. Although preliminary analysis of data shows interesting changes over time, the true value of the effectiveness of the strategies can only be determined by further, closer analysis.

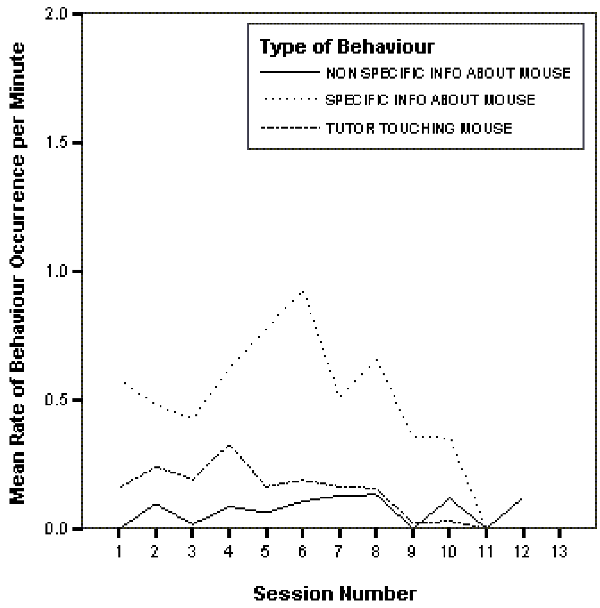

Figure 1. *Tutor behaviours relating to mouse.*

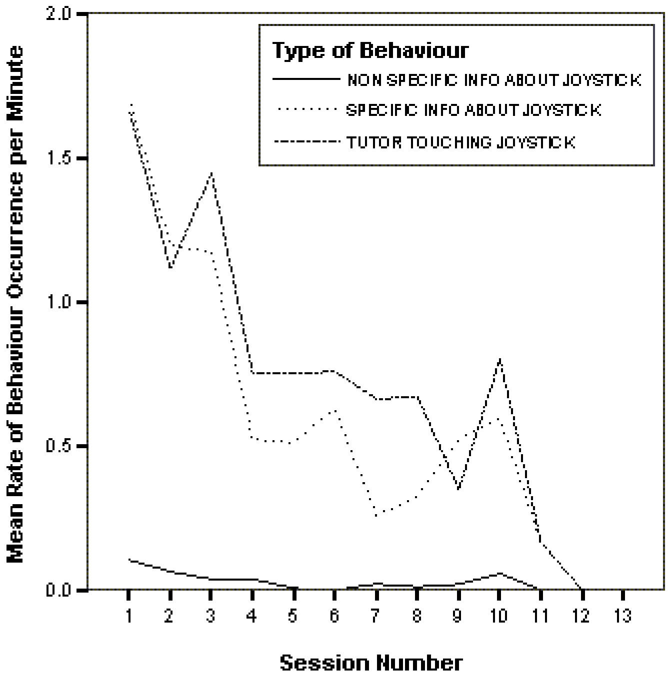

Figure 2. *Tutor behaviours relating to joystick.*

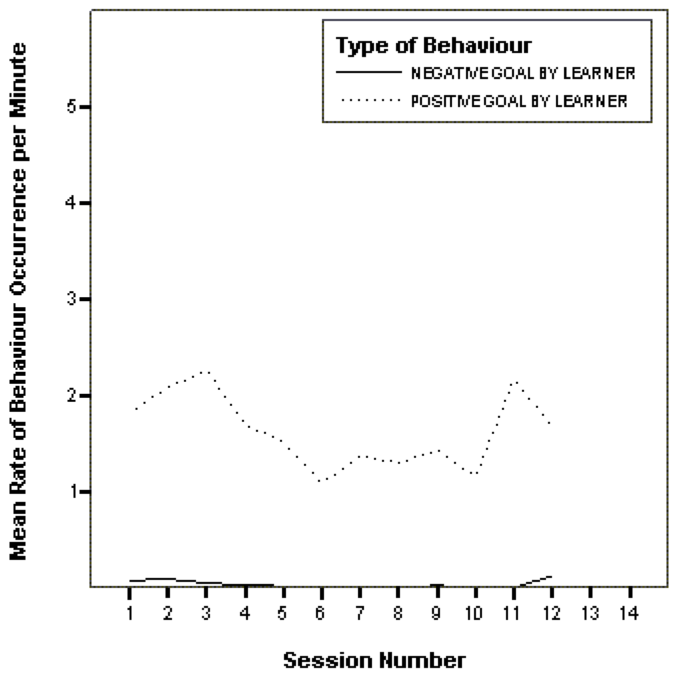

Figure 3. *Goals achieved by learner.*

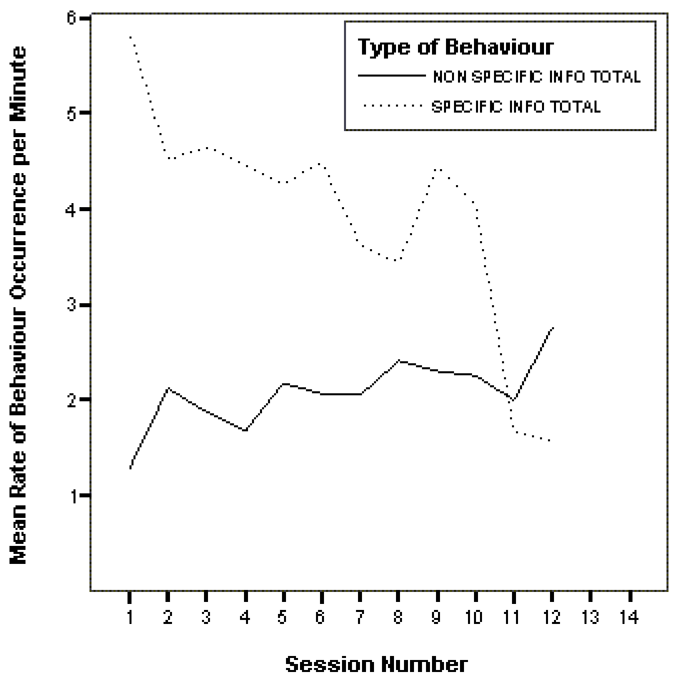

Figure 4. *Type of information given by tutor.*

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ICDVRAT 2000

Session VI. Virtual Environments & Autism

Chair: Elizabeth Attree

Employing virtual reality for aiding the organisation of autistic children behaviour in everyday tasks

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ABSTRACT

This paper documents part of a research project under the title: "Computer-Assisted Education and Communication of Individuals with Autistic Syndrome", which aims at designing and developing computer-based environments for aiding the education and assessment of autistic children. The theoretical basis of the project is explained. Finally, a scenario titled "Returning Home" for a virtual reality application, which would aid educators in organising the behaviour of autistic children in a series of everyday activities, is described.

1. INTRODUCTION

It is widely accepted that autistic children perceive the world and human behaviour in a unique manner. Autistic perception is governed by an idiosyncratic way of processing information. Most therapies and educative methods aim at being more effective by adjusting and meeting the specific needs of "autistic" understanding. Some of these needs make the use of virtual reality technology more relevant to the education of autistics.

One of the hypotheses about the phenomenology of the autistic syndrome is that autism derives from a lack of coherence in the processing of new information (Frith, 1989). The main difficulty of autistics is in understanding higher human mental activities, like expression of emotions, motives, beliefs and intentions, ultimately resulting in disabling communication. Therefore, the lack of coherence and the fragmented perception of autistics could justify characterising the world conceived by them as "*virtual"*. In this sense, it could be hypothesised that if we present autistic children with a *"virtual"* world, appropriately designed and adapted to their individual manner of conceiving reality, we may aid them in processing information and functioning accordingly.

This paper documents part of a research project under the title: "Computer-Assisted Education and Communication of Individuals with Autistic Syndrome", funded by the General Secretariat of Research and Technology of Greece and coordinated by the Department of Informatics, University of Athens. The aim of this project has been to design and develop computer-based environments for aiding the education and assessment of individuals with autism. An additional objective of the project has been to develop a web site for disseminating information and for aiding communication amongst professionals, parents and autistic individuals themselves.

Firstly, a literature review covering a range of issues regarding autism, including current ways of understanding at a biological and psychological level as well as educational – therapeutic approaches took place. At the same time, related computer-based environments for aiding autistic individuals were also reviewed. This phase led to a series of conclusions, which formulated the basis for this project, some of which are discussed in section (2) of this paper. Secondly, a pilot study took place for the purpose of testing the use of computer-based tools on children of this target group. This phase aimed at recording the responses of a range of autistic children to the use of such tools and is described briefly in section (3) of the paper.

Conclusions and observations from these two phases were taken into account in the design of a scenario (section (4) of the paper) describing in detail the exact sequence of events and consequent requirements for an interactive application that would aid the organisation of autistic childrens' behaviour in everyday activities. Finally it is suggested that virtual reality technology would be ideal for bringing this scenario to life. As this project is currently at its development phase, an indication of what has been achieved so far will be presented here.

2. COMPUTER-BASED LEARNING FOR AUTISM

The unique ways in which autistic individuals think and learn provide support for the view that the use of computers in aiding the learning process of these individuals will have many advantages. More specifically, Murray (1995) has suggested a list of characteristics provided by computer-based systems, which suit well the structured educational needs of autistics:

- clear boundaries
- controlled and step by step presentation of stimuli
- simple and obvious connection of information processed though one channel
- facilitating joint attention by selecting a compatible focus of interest
- restrictive context
- instilling feelings of safety, flexibility, adaptability and predictability of the learning environment or material
- enhancing development of autonomy, encouraging communication, boosting self-confidence and reinforcing optimism and respect.

Possible dangers involved in the use of computers for autism have been also discussed. These potential dangers can be compensated for by the appropriate incorporation of computer-based tools into a specifically organised teaching approach. It is not clear whether one could expect transfer of existing computer-based learning applications for autistic children to real world conditions. Similarly, placing such an application within an appropriate teaching context increases the possibility of achieving transfer of acquired knowledge to real world situations and consequently of enhancing generalisation (Jordan, 1995).

Taking all of the above into account, many aspects of effective learning can be promoted. In fact, several studies are in favour of the effectiveness of computers for educating autistics (Jordan & Powell, 1990, Heimann et al., 1995, Murray, 1995). The autistic child's involvement in the use of such a system may also become enjoyable without distracting from the learning target.

Virtual reality (VR) technology has already been successfully used in the treatment of phobias and in interventions to individuals with special needs. With reference to the autistic syndrome, Strickland et al. (1995) and Strickland (1997) have identified a series of VR technology characteristics, which justify its use by autistics:

- Immersive VR can isolate autistic individuals from their surroundings in order to help them focus on a specific situation.
- The complexity of a scene can be controlled.
- The lag of a VR system may not necessarily be problematic for an autistic; on the contrary it may prove useful towards aiding learning processes.
- VR technology allows for the successive and controlled adjustment of an environment with the aim of generalising activities at different but similar settings.
- A learning VE can be realistic, easily comprehensible and at the same time less hazardous and more forgiving than a real environment, when a mistake is made by the user. Thus, a VE provides us with a safe and controlled setting for developing skills for everyday life activities.
- The thought patterns of autistic individuals are mainly visual and a virtual environment (VE) builds on this specific visual skill.
- The present state of VR technology focuses on visual and auditory instead of haptic or other sensory stimuli. Specifically for autism, vision and hearing have proven to be very effective in the development of abstract concepts (Jordan & Powell, 1990).
- The use of tracking devices affords the possibility of monitoring the activities of an autistic, allowing for a re-adjustment of the system according to user's responses. Since a significant percentage of autistics never learn how to communicate, such a system may afford the possibility of interaction with simulated environments without verbal guidance provided by educators.

These characteristics correspond to the above mentioned list of factors for an effective educational system for autistic children. Moreover, a limited set of experiments (Strickland et al., 1995) have shown an encouraging adaptation of a small number of subjects to an immersive VE. This technology offers the ability to control and adjust a synthetic environment and this may prove useful for matching the needs and expectations of autistic children and consequently for teaching autistics how to respond to real world events and situations. However, more research is needed for establishing whether autistics can generalise the learning results achieved through interacting with different types of VEs.

Finally, it has to be stressed that "a gap exists between those who know about autism and the right questions to ask and those who know about the information technology and might come up with some of the answers" (Jordan, 1995). There has not yet been any computer-based application specifically developed for the autistic population in Greece. This project aims at being a first step towards this direction. It is important to mention that the team of individuals collaborating in this project consists of both people who specialise in autism and those who specialise in information technology.

3. PILOT PHASE OF THE PROJECT

The pilot phase of the project consisted of the following stages:

- A series of different types of multimedia learning environments were selected
- Educators of autistic children were trained during an intensive course into using these learning environments
- A pilot study took place in the specialist centres that collaborate in this project (EKAP, Pamakaristos) under the supervision of the trained educators
- The educators recorded their pupils responses to the selected learning environments in a specially prepared assessment sheet and were also encouraged to freely report their own impressions regarding the overall process. This fact was of particular importance since for most of them it had been their first experience of using such a tool in an educational process.

A sample of approximately 20 pupils, who had been officially diagnosed as autistic and with different levels of functioning, participated in the pilot phase.

4. "RETURNING HOME" A SCENARIO FOR EDUCATING AUTISTIC CHILDREN IN EVERYDAY TASKS

4.1 Background to the scenario

The essence of autism as a developmental disorder lies in the uneven and characteristic pattern of developmental psychological abilities, which results in an unusual combination of weaknesses and strengths. An educational program may be based on the existing areas of strength and could aim at enhancing weaker areas for the purpose of improving the overall level of functioning of the person.

The relationship between an autistic person and a non-autistic individual could be described through the metaphor of a wall, which is often being raised between them. Autistic children discourage people who try to relate to them because they do not adapt to their habits and wishes and because they rarely disrupt the regularity of their own persistent interests. One very important consequence of this behaviour is the disruption of learning even the most basic everyday activities like eating routines, washing and dressing in a consistent way. It is even more difficult for them to represent these activities. Additionally, they do not feel the need for imitating daily activities while playing.

Verbal communication is limited and as a result autistic individuals cannot easily comprehend spoken language or pay attention to the language addressed to them, while their comprehension is limited to a concrete understanding of things. It is therefore understood that their educator cannot be supported by spoken language and dialogue for teaching useful activities and enhancing their behaviour.

These facts have led to an identification of alternative ways of communicating in combination with addressing the children's stronger areas of functioning, like visual perception. Autistic children have accurately been characterised as "visual learners". In this respect, the use of symbol-cards (or icon-cards), within a structured educational context, has proved to be very useful in overcoming certain difficulties. Whenever language understanding fails to support communication, the symbol-card along with its inherent rules offers an alternative way of “speaking”: simple, unambiguous and specific. As a result, the autistic children’s communication with their environment may be compensated to a certain extend.

The use of the symbol-card helps children feel comfort and even pleasure after making the effort to respond to what the card presents. The icon displayed on the card is carefully designed so as to visualise the meaning of spoken language in the best possible manner. It helps autistic children feel safe and express themselves verbally, when possible. When children are not capable of speaking, they can express their needs through a card. The use of symbol-cards during playing or other activities seems to also have rewarding results for the promotion of speech and independent performance during activities.

The well known and widely accepted TEACCH program approach incorporates the use of visual representation of things and events including symbol-cards and places them in discrete sets of sequences, thus providing good support for the above mentioned views.

4.2 Description of the scenario

According to (4.1), a scenario under the title “Returning home” was designed in the form of a simulated environment addressing the visual perception of the child. The aim of the scenario was to provide the educator with a tool, which would improve his potential for effective teaching. More precisely, the content of this scenario could help him achieve a coherent organisation of certain important everyday activities, provided that it is appropriately incorporated within an overall teaching strategy.

In fact, “returning home”, including the use of cards but in its non computer-based form, is a scenario which has been used in recent years, in everyday practice with autistic children. Through our direct experience with this scenario, it has been evident that children respond well and acquire a better understanding by making use of this approach. In search for a potentially successful “returning home” scenario in a computer-based form, the significant issues of using symbol-cards, speed of presenting information, quality of colour and sound, coupling of icons and corresponding words and several other aspects were addressed by the design team. The symbol-cards used in this application are the MAKATON symbol cards, which were provided to the project by the “Makaton Hellas” official representative.

The points, which were specifically taken into account while designing the scenario for the exercise, were the following:

1. Symbol-cards should precede each presented activity so that autistic children may focus their attention and understand a series of everyday life routines like eating, dressing, sleeping etc.
2. Special attention was given to the order and speed of presentation. It has been observed that autistic children respond better when a series of events follows a certain order and when the speed with which these activities are presented corresponds with their own individual rhythm. This may rid autistic children of the stressful and chaotic behaviour by letting them know of what will happen next. The symbol-card and the appropriate point of presenting this card are always crucial for the proper execution of the exercise.
3. The colours, which surround the presented images, are pastel and continuous. They should not be very vivid as this would call off their attention and would seduce them into non-functional stimuli.
4. Autistic children perceive sounds in a very special manner. While they may not respond to a person speaking to them at all, certain not very significant sounds may easily draw their attention. In cases of children with advanced musical education, music does not seem to have an enjoyable effect on them but is simply perceived per se. Therefore, any auditory enhancement of the interactive system should be very carefully designed with the aim of activating the children but without upsetting them.
5. Specific care should be taken into writing words, either in the form of icon labels or as stand alone signs, since the «literal» mind of autistic children may make them focus on one of these words and, without interpreting the correct meaning of the word, lead them to a wrong choice of action. There is also a danger that a label under an icon may distract from the icon itself or trap them into one single letter of a word. It is therefore important that icons are relatively abstract and unambiguous.
6. Re-enactment can be seen as a method of playing. Since the mind of autistics is «literal» and lacks imaginative thinking, playing activities should also be taught. Inherent in this difficulty is the fact that autistics cannot easily distinguish between the real and the imaginative. A way of achieving this could be through clearly determining the boundaries for a certain sub-space, within which imaginary events and activities are allowed to take place. Real world events take place outside this sub-space, thus clarifying the concept of «reality» for the autistic child.

These points were seen as requirements for the application to be designed.

This application aims to be another tool for aiding the very difficult task of educating autistics. The scenario will be implemented in an individualised one-to-one base. Therefore, this tool should be somehow adaptable to the individual's level of functioning and consequent educational needs. In order to achieve such an adaptation, the application would have to provide the educator with the opportunity to:

1. Select between two modes of functionality (A and B), corresponding to individuals with a lower level of functioning (A) and to individuals with a higher level of functioning (B).
   - The former mode is relatively passive involving the individual only in pressing a button for triggering the next sequence of activities.
   - The latter mode is relatively more active, involving the individual into navigating within the simulated environment and interacting with specific 2D or 3D objects in a constrained manner.
2. Select amongst a series of certain sequences of activities to be presented to each autistic individual in a certain order.

The application presents autistic children with possible everyday activities that may take place when a child returns home. They are able to navigate within this virtual environment, follow a virtual character demonstrating these everyday activities and interact with elements of the interface (2D or 3D) in order to trigger certain actions within the scene. After the completion of an activity, a symbol-card prompts the autistic child to act in order to trigger the next activity to be executed.

The entry setting for the application presents the child with an environment, comprising an arhetypal two-storey house and a road from which the virtual character arrives by a school bus. The mother greets the virtual character, who enters the house. On entering, the child is presented with a plain, longitudinal space, from where one can access the 5 rooms of the house where activities will take place: bathroom, kitchen, child's room, parents' room and living room. Each of the rooms has a symbol-card positioned on its door to indicate its function. In mode (B), movement of the virtual character is controlled by the autistic child by making use of an appropriate input device. In mode (A), the child simply triggers one sequence after the other, automatically following the animated virtual character who executes a sequence of everyday basic activities.

Figure 1. *The virtual character demonstrating the activity of "washing hands".*

Following the brief description of the scenario, the appropriate technology for implementing this scenario was identified. This process took into account the degree to which the technology satisfied the requirements described by the scenario. These requirements dictated the design of a three-dimensional environment, within which an animated character could perform a series of activities, the autistic individual could navigate and follow the character in a relatively controlled manner and interaction with certain 2D and 3D interface elements is supported. This environment could only be implemented by making use of VR technology.

5. CONCLUSIONS

The uniqueness of the autistic syndrome and the diversity of its symptomatology has directed the scientific team of the presented paper into designing an explorative, structured environment. Specialist trainers of autistic children urge for the development of parametrical environments, which could be adjusted to each individual case of an autistic child.

Currently the application is at the development stage. After completion, an evaluation will take place, in which a number of autistic children, will participate. These children will have been assessed in terms of their language and learning abilities, as well as level of functioning.

The proposed application is not seen as a panacea. It is understood that it is difficult to find a scenario equally suitable for every autistic child. However, the relatively parametrical nature of the proposed virtual environment application is expected to compensate to a degree for this inherent problem.

At this stage, the proposed environment is primarily a tool designed for aiding autistic children educators at their very difficult task. It is also important to stress the fact that this environment does not aim to substitute existing educational approaches for autistic children but rather to enrich them. Such an application could only be utilised if it is incorporated within the context of an overall educational strategy.

The designed environment implements structured tasks for training, relative to the specific needs of these children and utilises a VE system in order to filter and control environmental distractions, which may negatively affect autistic users. It is anticipated that this filtered environment and the training structured tasks could generate the interest and provoke the engagement of autistic users. With the proposed VE, the trainer could design highly filtered, structured and controlled tasks, assisted with techniques of driven attention and paired with the corresponding communication cards, to match the individual learning needs of an autistic user. In the mean time, certain aspects of this scenario could be utilised for promoting a series of secondary skills, which could also be considered as educational targets.

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