

Virtual reality in vocational training of people with learning disabilities

F D Rose, B M Brooks and E A Attree

Department of Psychology, University of East London, Romford Road, Stratford, London, UK

f.d.rose@uel.ac.uk, b.m.brooks@uel.ac.uk, e.a.attree@uel.ac.uk

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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