# DEVELOPMENT AND EVALUATION OF THE VIRTUAL CITY

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## ABSTRACT

This paper describes the initial development of the Virtual Life Skills project. A user-centred design approach was developed to build virtual environments (VEs) intended to provide a practice arena for skill learning in children and adults with learning disabilities. The context for learning these skills is a computer generated model of a city in which users have freedom to explore different buildings and practice a variety of everyday living skills.

Ideas for components of the Virtual City were generated via a User Group formed of people with learning disabilities working with a facilitator. This group generated a series of storyboards which were used as prototypes from which programmers constructed this computer aided learning (CAL) package. In the first year of the project four components of the Virtual City have been developed: a house, a supermarket, a café and a transport system.

Evaluation of the project was concerned as much with the design of the virtual learning environments (VLEs), issues of usability and access as with monitoring skill learning and transfer to the real world. For three of the VLEs, Supermarket, Café and Transport, a test-retest experimental design method was used. This compared user performance in real world tasks with the same tasks presented in the VLE. Expert assessment was used to evaluate the Virtual House, looking at usability and appropriateness of the learning scenarios. It was found that VLEs can provide interesting, motivating learning environments, which are accessible to users with special needs. Individuals differed in the amount of support required to use the input devices and achieve task objectives in the VLE. Expert and user review methods indicated that the VLEs are seen to be representative of real world tasks and that users are able to learn some basic skills. However, it would be unrealistic to expect transfer of skill over a short experimental time. Further testing is needed to establish the longitudinal learning effects and to develop more reliable techniques to allow users to express their own opinions.

Within this project the value of a user centred approach has been demonstrated. The groups involved have provided informed input at each stage of VE development. This has been enhanced by contributions from experts in the field of learning disabilities. The Virtual City has been developed in response to the needs of people with learning disabilities, not in response to their assumed needs.

## 1. Introduction

In the early 1990s researchers were beginning to consider the exciting potentials of Virtual Reality (VR) for education (Stuart & Thomas, 1991; Helsel, 1992). There was also some interest at this point in the use of VR for the education of individuals with learning disabilities (Middleton, 1992; Powers and Darrow, 1994). VR systems have subsequently been developed for users with physical disabilities (Greenleaf, 1992, Stanton et al., 1996), vision impairments (Loomis et al., 1993) and hearing impairments (Vamplew & Adams, 1992).

Despite growing numbers of VR applications within special needs and mainstream education, there is still little evidence of research concerning the profitable use of VR with users with mental retardation and cognitive impairments (Darrow, 1995; Youngblut, 1998). This may be due to a combination of many factors but one particular knot in the problem may be due to the resources required when attempting to develop Virtual Learning Environments (VLEs) for this particular user group.

Any real attempt to give a non-tokenistic voice to users in the development and testing of such a project would involve the co-ordination of user and professional groups, community links for volunteer testing sites, ethical practice committees, and community groups. Underpinning this coordinated effort should be a drive to produce learning tools developed on new technologies which are accessible and affordable for prospective users. Training methods for people with learning disabilities are notoriously problematic (e.g. Stokes & Baer, 1977; Ward & Gow, 1982), and so before any large-scale development of VR based tuition in learning disability takes place the fundamental issue of its efficacy must be addressed. Brown et al (in press) details an anthology of research work undertaken at the University of Nottingham in collaboration with user groups addressing this issue. Other research has tried to minimise the difficulties faced from working with a disabled population by testing virtual environments with participants not representative of the intended user population. This is often used as a first step in the evaluation process (Jones, 1998; Jonassen, 1998).

Something which may hinder the development of Virtual Environments for users with disabilities are the decisions by advocates that Virtual Reality may not be accessible or appropriate for disabled users. This opinion may come from their own uncertainties or fears of the technology. There may also be resistance or overprotection from other adults, parents, teachers or caregivers.

Previous research carried out by the authors has shown that children with severe learning disabilities (SLD) are able to navigate and interact with virtual learning environments (VLEs) (Brown et al., 1995; Brown et al., 1997a). Several studies were carried out to assess the use and development of suitable input devices to support the interaction and navigation tasks required in these VLEs (Crosier, 1996; Brown et al., 1997b, Lannen, 1997). An investigation into the transfer of skills from a VLE to the real world showed that students who had previously practised shopping skills using a VLE could complete these tasks more quickly and more accurately in the real world compared with a control group (Cromby et al., 1996). Researchers also examined three different types of VLEs used by students with special needs to develop independent living skills to investigate to what degree they supported the constructivist theories of learning (Brown et al., in press).

The early evidence of the effectiveness of VLEs in special education prompted the initiation of the Virtual Life Skills Project. Community groups who had become familiar with VLEs built by VIRART identified the potential for future applications of virtual environments as a practice arena for a range of life skills. Given technological advances occurring during this period, it was felt that the time was right to define more structured development and integrated evaluation methodologies in the project. It was decided that the best way to facilitate the learning of independent living was to build a comprehensive Virtual City. This would replicate the variety and complexity of real world settings to enable individuals with learning disabilities to learn and practise important life skills in preparation for independent living. Four components of the Virtual City were completed: Virtual Supermarket; Virtual Café; Virtual House and Transport System.

## 2. Project Overview

The Project Consortium was made up of representative organisations that provide services to children and adults with a learning disability and/or difficulty. This meant that the project involved disabled people from many areas ensuring the final product would have as wide an audience as possible. The User Group, Testing Group and Steering Group also included members from different disciplines. This allowed people from different backgrounds, ages and abilities to be involved in the production, development and evaluation, having a real influence on the product.

The project as a whole implemented a user centred approach to the design and evaluation of the proposed VLEs. Figure 1 represents the overall project methodology. VLE design specifications were created as follows:

- A project User Group, comprising representative users from the community groups previously mentioned specified tasks or skills they wanted to learn within each VLE.
- A project Steering Group, comprising professionals who work with learning disabled clients or students, identified specific user requirements and learning objectives appropriate to the skills to be developed.
- Storyboards were drawn up representing each VLE design.

The various groups involved in the Project all individually provide services to people with a learning disability or difficulty in Nottinghamshire. The organisations included a Housing Association, Local Authority, NHS Trust, a school for people with severe learning difficulties, an organisation providing residential accommodation, a University, and a College of Further Education. Initial meetings highlighted differences of communication, terms and focus of interest between the

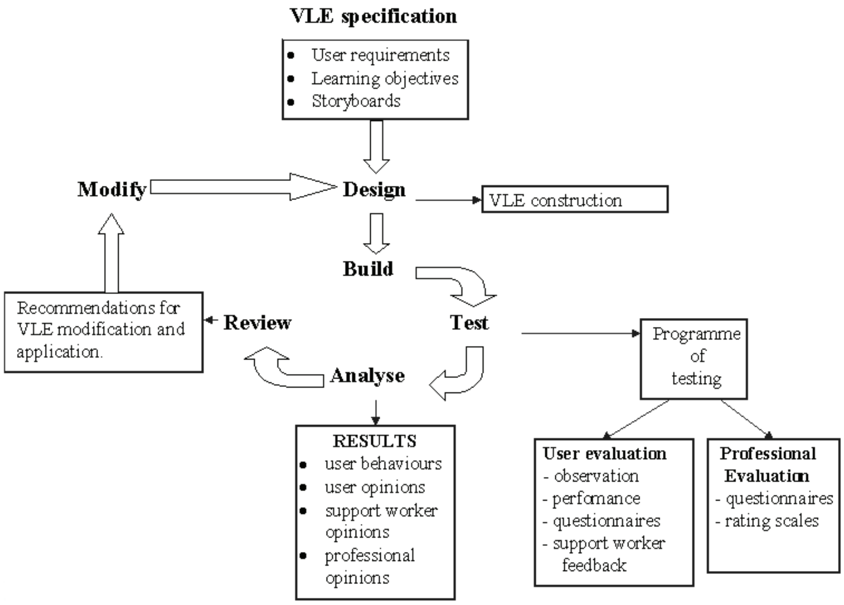


*Figure 1. VLE design and evaluation methodology*

disciplines. This forced the groups to bring consistency to their way of working and use effectively the diverse range of knowledge and experience.

During the construction phase, members of the User Group and Steering Group regularly reviewed the developments to ensure that they were being built within the original vision of the storyboards.

When completed, a programme of testing was carried out to assess the suitability of these VLEs for the learning of independent living skills by this user group. Evaluations were carried out by users and professionals using a variety of measures; including performance of tasks under experimental conditions, observations of usability, questionnaires and informal interviews. The results produced recommendations for design changes to each of the VLEs.

## 3. Virtual Learning Environment Specification

One of the main aims of the project was the involvement of individuals with learning disabilities in the development of the Virtual City. Meakin et al., (1998) describes the User Group involvement in the Virtual Life Skills project. It is uncommon in the wider scientific community for users to be an integral part of the design process, but in this case, User Group involvement ensured the relevance and accessibility of the end product. What proved important was that the users developed a sense of ownership of the project and that their needs and interests were represented in the design of the Virtual City. By this process we hope to meet the criteria set by other researchers to produce; "research which more clearly benefits the people whom it is supposed to help." (Minkes et al, 1995).

Fifteen representative users worked together with a facilitator to provide effective advocacy, and met every month to brainstorm ideas about what components they thought should be included in a Virtual City and what tasks they would like to practice in each. Members of this group were recruited from each of the community groups involved in the project and selected to ensure a balance of age, gender, disability and cultural heritage. The group initially identified 38 modules they wanted to be included, ranging from a cinema and a pub, to a railway station and a health centre. The User Group also decided what was important to them and what they wanted to be able to do in each module.

The facilitator's role was to present the project requirements to the users, erasing the need for text, and communicating with users through accessible language and pictures. They also prompted users to expand on their ideas and provide more detailed answers, by providing unbiased background information on topics raised by the users, enabling them to make informed choices. The User Group took the decision to achieve consensus democratically as shown in the following example:

User 1 *"We want to learn about safety"*
Facilitator: *"What sort of things would you like to learn about?"*
User 1: *"We would like to learn about burglar alarms"*
User 2: *"Nobody has burglar alarms"*
Facilitator: *"Some places do – like group homes or schools or hospitals"*
User 1: *"Yes, they do"*
Facilitator: *"So, do you want to learn about burglar alarms?"*
User 1: *"I don't mind"*
User 2: *"I don't mind"*
Facilitator: *"What does everybody else think?"*
User 1: *"Let's have a vote"*

Cartoon style storyboards were used to represent users ideas as pictures as they were provided in the User Group meetings. As the visual images were drawn the facilitator provided a simultaneous verbal explanation. The advantage of storyboarding was to give the users an opportunity to visualise their ideas and to decide if that was how they wanted the virtual environment to be. The storyboards proved both effective and popular with users:

*"I like using pictures, because I can't read."*
*"It's easier because you can see what people mean."*
*"If it's not right, I can say so and then it can be changed."*

These first storyboards were then taken to the Steering Group for final approval. The role of the Steering Group was to identify suitable learning objectives associated with the scenarios defined by the User Group. A final storyboard detailing layout, structure, learning objectives and dialogue was then drawn up for each component. Figures 2 and 3 (only on the CDROM) show draft and final storyboards for the Virtual House.

On the basis of the final storyboards a virtual environment building programme was specified. Components of the Virtual City were built individually using the Superscape VRT platform. This would allow the Virtual City to be accessible to a wide range of users as it could be viewed on a standard desktop PC. Throughout the building phase members of the User Group and Steering Group held regular review meetings to assess progress of the virtual environments in accordance with the approved storyboards.

## 4. The Virtual City

For each of the four components of the Virtual City, sets of learning objectives relevant to life skills were defined. These learning objectives were used as the basis for evaluation of skill performance both in the real world and in use of the individual virtual environments.

### *4.1 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 in Figure 4 and 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

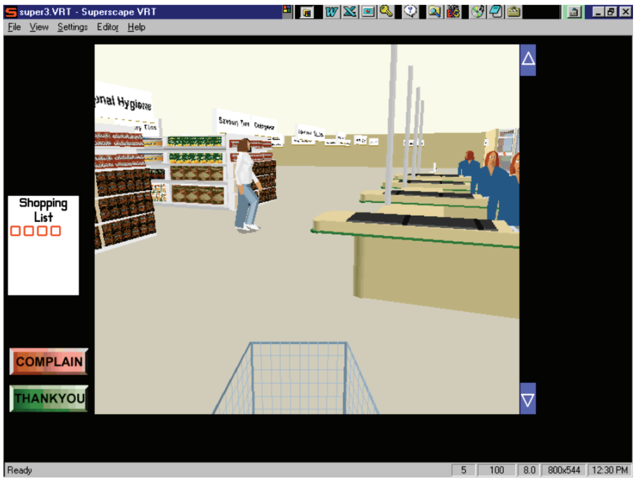


*Figure 4. Virtual Supermarket*

## *4.2 VIRTUAL CAFE*

The contents and layout of the virtual café were based upon the University of Nottingham's Art Centre Café. The steering group thought that this would make it easy to test this environment as we could readily establish whether skills developed in this virtual environment transferred to a real and accessible environment. The Virtual Café is illustrated in Figure 5 and learning objectives identified for this environment are as follows:

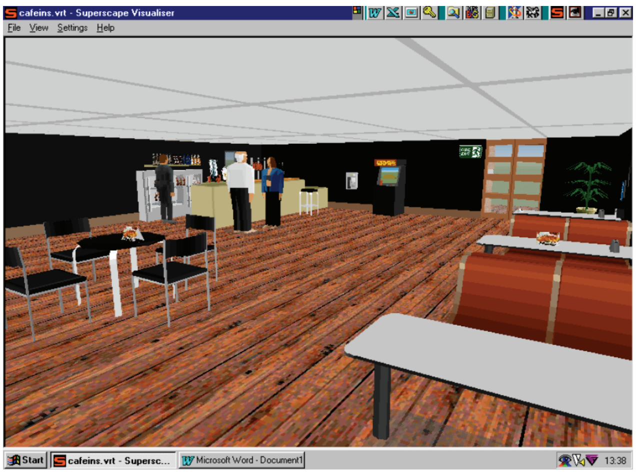


*Figure 5. Virtual Cafe*

- 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

## 4.3 VIRTUAL HOUSE

The Virtual House was not based on one particular house design but used a standard layout, consisting of a living room, kitchen, bathroom and bedrooms. The Virtual House is illustrated in Figure 6 and learning objectives identified for this environment are as follows:

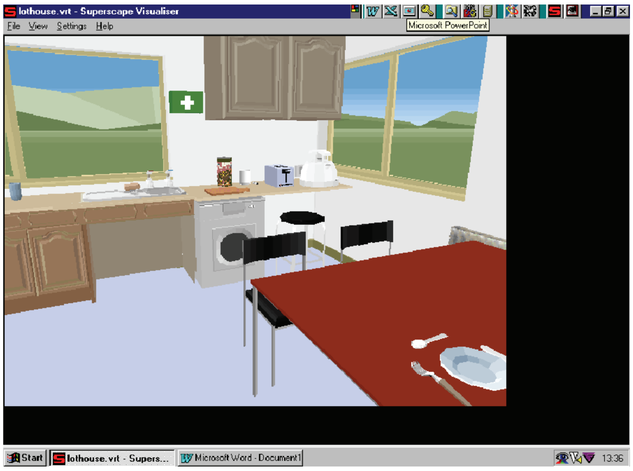


*Figure 6. Virtual House*

Appropriate dressing skills dependent on weather conditions

- Appropriate public and private areas of the house
- Hygienic use of the toilet
- Problem solving:dealing with emergencies (e.g. fire, burglary)
- What goes where (unpack the shopping in the kitchen)
- Preparation of a simple meal
- Use of equipment (cooker, fridge, TV)
- Safety issues:dangers of knives, cookers

## *4.4 VIRTUAL TRANSPORT*

The Virtual Transport system was designed as a way of physically linking the other three VLEs. Thus, the tester could take the bus from the house to the supermarket, or to the café, etc. The bus route was not modeled on any actual location but the buses themselves were made to resemble Nottingham City buses which the testers would be using. The Virtual Transport environment is illustrated in Figure 7 and learning objectives identified for this VLE 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

## 5. Objectives of the Evaluation Study

In addition to testing the suitability of the VLE designs for users with learning disabilities, the evaluation study was set up to identify benefits of using the Virtual City (Cobb et al., 1998). Four desirable outcomes of the project were identified in a previous evaluation study (Brown et al., in press):

- Usability – that users can access the computer programmes appropriately
- Enjoyment – that they like using them and want to explore the VLEs
- Skill learning – that from exploration and practice in the VLE users are better prepared to carry out certain real life tasks
- Transfer of skills – that users can apply their new knowledge and skills into their everyday life

The ultimate objective of the Life Skills project was to assist development and improvement of real world skills. However, it was recognised that there may be many factors influencing learning from use of VLEs. For example, usability and access issues would have a huge influence on learning from any computer-based programme (Shaw et al., 1995).

This aspect was perhaps the most influential in determining support worker/advocates' initial impressions – if users couldn't control the computer then how could they learn anything from it? The evaluation study had to consider this and so background information concerning users' abilities and experience of computers was obtained and measures of computer skill were tracked throughout the testing programme.

It was also recognised that it may be too ambitious to expect to see changes in real world skill levels within the short time frame of this project. Other outcomes which may be necessary foundations for later skill learning should also be identified. One example would be enjoyment from interacting with the VLEs. If a user enjoys the VLEs then they would be more motivated to use them again and to explore new features within the programme. This self-motivation, together with the advantages of 'learning by doing' and exploration, is ideal for learning in any context. The evaluation study therefore had to be broad enough to identify *any* benefits from using the Virtual City irrespective of their influence on skill level.

## 6. Evaluation Programme


*Figure 7. Virtual Transport*

Figure 8 illustrates the evaluation procedures used to assess each of the virtual learning environments. For three of the VLEs, Supermarket, Café and Transport, a test-retest experimental design method was used which compared user performance in real world tasks with the same tasks presented in the virtual environment. This was not possible for the Virtual House and so the assessment was based on expert and user comments on usability and design features of the Virtual House in support of the learning objectives.

### *6.1 PARTICIPANTS*

In line with the user-centred approach to design and development taken in this project, the evaluation study was based on user trials. It is important to acknowledge that these 'users' were not being assessed in their use of a completed product but were contributing to its development. For this reason 'users', representing the target user population, are described as 'testers'.

It was important to the project that a range of testers with different abilities and backgrounds took part in the study. Individuals from a variety of community centres were invited to participate in the evaluation study. Background demographic information (age, gender, reading ability, numeracy, comprehension, physical disability and computer use) was obtained via questionnaire.

Fourteen testers completed the experimental study, seven male and seven female. These testers represented a wide range of ages (from 14 to over 50) abilities and backgrounds. Comprehension varied from simple spoken English only to understanding complex sentences. Reading ability varied from name only and signs or symbols to reading a daily newspaper. Numeracy varied from none to adding to 100 and subtracting from 50. All of the testers had

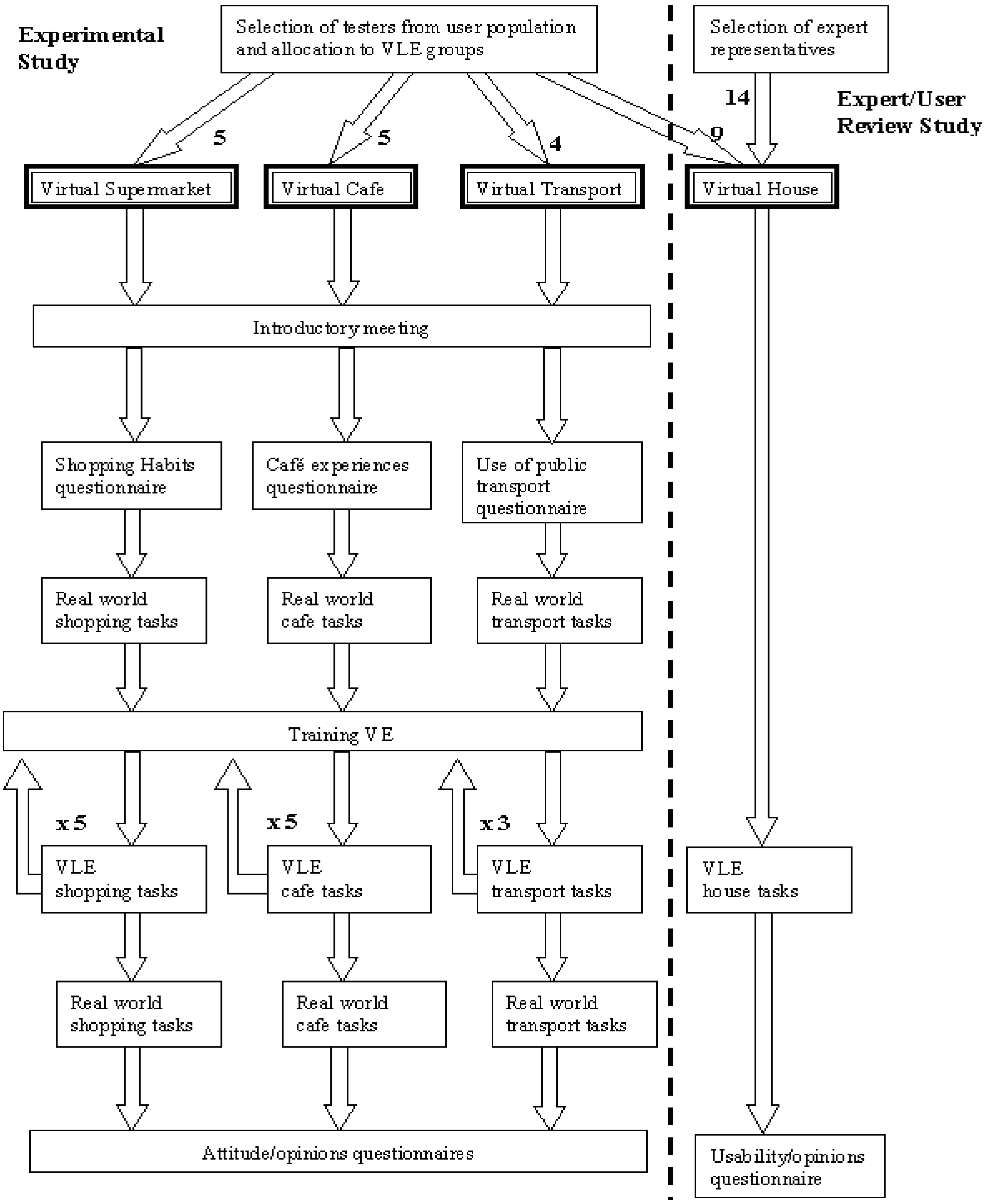


*Figure 8. Experimental method*

used a computer before, but 5 out of 14 had never used a joystick. All of the testers needed some support although the questionnaire did not identify the extent of this.

Fourteen expert representatives from the learning disabilities community took part in the evaluation study of the Virtual House. These included five housing support workers, four social workers, three day centre advisors, one occupational therapist and one teacher from the Nottingham area. All were representing adults with learning disabilities. Nine female and five male in the 20-50 age group. All except one had used computers and five had some previous experience of VR, mostly via a similar housing project.

Nine users also took part in the evaluation study of the Virtual House. These were members of the project User Group who had defined the initial specifications for each of the VLEs. As such, they were familiar with the objectives of the Life Skills project and were experienced in using virtual environments. They represented a similar range of user backgrounds to the testers.

*6.2 EXPERIMENTAL STUDY*

An introductory meeting allowed testers to complete 'habits questionnaires'. These were relevant to the VLE that they would be testing and provided useful information concerning the testers' skill levels and also a basis upon which to assess the potential relevance and impact of VLE training for each individual. For example, if a tester goes shopping on a weekly basis but cannot go unassisted, then training in the Virtual Supermarket is relevant to them. If, at the end of the project or at some later date, they are able to go shopping independently, then the VLE training may also have had high impact on their life skill development.

Figure 8 shows the test-retest method used in this section of testing. At the first scheduled testing session the tester, together with their support worker, completed a number of tasks in a real environment. The experimenter recorded how much support the tester requested or was offered by the support worker for each activity with specific interest in who was making decisions and how much prompting the tester needed to complete tasks.

One week later the tester and support worker visited the University of Nottingham to start the VLE training sessions. They completed tasks, similar to those completed in the real environment, in the VLE. These sessions were video recorded to allow the experimenter to further analyse the activities. The experimenter also observed specific difficulties faced in using the computer program.

One week after completion of the training sessions the tester and support worker repeated the tasks in the real environment. The experimenter recorded the activity in exactly the same way as before. When all testing sessions had finished the support workers completed attitude and opinions questionnaires.

*6.3 EXPERT/USER REVIEW STUDY*

All participants attended one of three sessions at the University of Nottingham. When they arrived they completed background details questionnaires. A presentation was given describing the Life Skills project and they were shown a demonstration of the Virtual House. Working individually, they then spent up to one hour exploring the Virtual House. During this time they completed a detailed questionnaire describing their impressions of the Virtual House features; how easy or difficult they found it to do, how easily they thought that their clients would find it and how appropriate the scenarios were for teaching the learning objectives defined.

The Users followed exactly the same procedure but

| Usability problem | Category | Refinement to VLE design |
|---|---|---|
| S2.1 Create a list option<br>S2.2 Choose food categories<br>C2.1 Enter personal details<br>C2.3 Sit here? Screen text overlay<br>C2.4 Menu – screen text overlay<br>C2.6 Wash hands – screen text overlay<br>T2.1 Show and try buttons<br>T2.2 Use of text boxes<br>T2.3 Select destination<br>T7.3 Get off bus at correct stop by clicking on text box | **Reading text problems (10)** | **Increase use of Makaton symbols<br>Standardise 'yes' 'no' 'move on' with colours, symbols and position.<br>Speech therapist to simplify any text and suggest symbols.** |
| S2.3 Select item activates small number<br>C2.5 Click food activates small tick in box<br>S2.14, C2.8 Paying – click on coin activates small numeral (denotes how many chosen) | **Unsure of effect of action (4)** | **Highlight object –red outline when selected<br>Transfer coin selected to representation of hand – real world clue provided.** |
| C2.2 Bump into table to sit down<br>S2.11 Bump into cash desk to allow loading of goods | **Not naturalistic action/interaction metaphor (2)** | **Allow interaction using mouse<br>Can position trolley in larger area next to cash desk** |
| S2.7 Collecting trolley – small area to click on<br>C2.5 Choose the food – small area to click on<br>T7.2 Confusing to click on coin box, ticket machine and driver – due to arrows<br>C2.11 Use toilet in café overlapped/confusing instructions as to what to click on and in what order. | **Problems to interact with object (4)** | **Enlarge object/provide closer automatic viewpoint<br>Highlight object by making it red and flashing<br>Clarify verbal instructions given – speech therapist input** |
| S2.5 Enter doors of supermarket<br>C2.10 Enter the toilets<br>T4.1 Position at shelves | **Navigation problems (3)** | **Make doors wider, double doors open together automatic close is slowed/stopped<br>Provide auto viewpoint at shelves** |
| S2.4 Current state of list is not known when creating it<br>S2.6 Difficulty finding product areas and individual products<br>S2.9 In VLE extra step needed to use shopping list<br>S2.14, C2.8, T4.2 Payment – no opportunity to select different coins and then change your mind – use different ones.<br>T4.2 Recognition of coins | **VLE does not provide enough/ same clues as real world (7)** | **Provide clues which reflect those given in the real world e.g. – can see representation of list when creating it, coins/notes more realistic<br>Increase clues (more than you would have in real world) given to help usability of VLE – e.g. picture/symbol signs in supermarket** |

*Table 1. Usability Content Analysis*

were provided with a simplified version of the questionnaire and had support in completing the questionnaires during exploration of the Virtual House.

## 7. Evaluation methods and results

Three data collection methods were used during the programme of testing as follows:

1. Observation of tester behaviour in use of the VLEs and performance of real world tasks;
2. Tester attitudes and opinions derived from questionnaires and discussion sessions.
3. Feedback from support workers regarding tester performance and attitudes;

A variety of measures were applied in order to identify the four desirable outcomes of the project:

- Usability issues (measures of access and control over the VLEs)
- Enjoyment (tester/support worker comments and opinions)
- Skill learning (Expert/support worker opinions of testers' skill development)
- Transfer of training (measures of performance/attitude changes before and after VLE use)

*7.1 USABILITY*

Usability refers to the suitability of the VLEs for the individual needs of the user population. This is particularly important in a project of this kind since there are many potential barriers to learning, such as low reading ability, inexperience of computers, etc. If VLEs are to have any contribution to skills training and transfer to the real world, it is vital that they do not present an additional barrier to learning through poor usability. In this project usability was assessed in three ways: tester control of the computer-input devices; tester behaviour in the VLE and response to instructions; and support worker assistance given during VLE use.

In the experimental study it was found that all of the testers could use both the joystick for navigation and the mouse for interaction. However different levels of support were needed to use the input devices and complete tasks. One tester had a physical disability which meant that she could not use the mouse without physical assistance but understood the mouse 'concept' and would have been able to use a different device on her own. Ability to use the input devices was seen to improve during the course of the experiment. Observation of testers using the computer yielded a positive change in support worker attitudes concerning tester ability to use the computer and its input devices.

A usability content analysis was performed on the observation and questionnaire data (summarised in Table 1). The categories summarise the type of problem and display the frequency of this type of usability problem found. For each problem type, design properties relating to the VLEs were defined. These, if refined, could increase support given in this activity and increase its usability. For example, user interactions could be supported by providing standard coloured symbols with a simple text voice over, replacing a text box. Suggested refinements to improve VLE usability in all categories are summarised in table 1.

Usability assessment for the Virtual House was based on expert and user responses to questions regarding how easy or difficult they found it to complete the tasks in each room. The responses are summarised in tables 2,3 & 4. It was found that to explore all of the activities in the Virtual House could take up to an hour. Not everyone could afford this much time and so some questions could not be answered.

| | Easy /v. easy | Difficult / v. difficult |
|---|---|---|
| Find your way around the house | 79% | 7% |
| Know where you were in the house | 86% | 0 |
| Move around using the joystick | 50% | 21% |
| Position the cursor over objects | 79% | 7% |
| Activate objects using the mouse | 71% | 14% |
| Understand what you were expected to do | 93% | 0 |

*Table 2. Experts review of usability for themselves*

| | Easy /v. easy | Difficult / v. difficult |
|---|---|---|
| Find their way around the house | 31% | 38% |
| Know where they were in the house | 54% | 15% |
| Move around using the joystick | 0 | 54% |
| Position the cursor over objects | 23% | 46% |
| Activate objects using the mouse | 23% | 31% |
| Understand what they were expected to do | 38% | 23% |

*Table 3. Expert review of usability on behalf of users*

| | Easy | difficult |
|---|---|---|
| Find your way around the house | 100% | 0 |
| Know where you were in the house | 100% | 0 |
| Move around using the joystick | 66% | 33% |
| Position the cursor over objects | 50% | 50% |
| Activate objects using the mouse | 66% | 33% |
| Understand what you were expected to do | 100% | 0 |

*Table 4. Users review of Usability for themselves*

It can be seen that the experts experienced few difficulties in using the Virtual House but anticipated that users from the special needs groups that they represented would. However, the users themselves found that they could use the Virtual House – the only difficulties reported were related to use of the computer input devices.

*7.2 ENJOYMENT*

| | **a) Collecting Trolley** | **b) Selecting Items** | **c) Paying for Bus** |
|---|---|---|---|
| Real World Pre VLE | Physical prompts | Support worker does | Support worker does |
| VLE session 1 | Support worker does | Physical prompts | Physical prompts |
| VLE session 2 | Physical prompts | Physical prompts | Physical prompts |
| VLE session 3 | Verbal prompts | Visual prompts | Visual prompts |
| VLE session 4 | Tester does alone | Tester does alone | Tester does alone |
| Real World Post VLE | Verbal prompts | Tester does alone | Tester does alone |

*Table 5. Support worker involvement in three tasks*

User enjoyment was assessed taking data from observing tester use of the VLE and using questionnaire answers from testers and support workers.

User attitudes, opinions and comments indicated that:

- There was a very high overall level of enjoyment.
- The testers experienced low levels of anxiety and frustration. Highest levels were reported in the first real world and VLE sessions.
- Navigation, although having been found as one of the most difficult tasks to do, was often stated as the most enjoyable aspect of using the VLE.

The support workers further consolidated this information by rating tester enjoyment on a seven point Likert scale. There was a significant change in attitudes before and after use of the VLEs reflecting that support workers reported that testers did enjoy using the VLEs more than expected. As an example, one support worker wrote *"Very much enjoyed using virtual environments and still talks about using them* [One month after the end of the testing period]".

*7.3 SKILL LEARNING AND TRANSFER*

To attribute any real world improvement to VLE use we need to also look at the testers performance in the VLE training sessions. This was done by looking at how performance changed over the real world and VLE sessions and recording tester and support worker feedback. Each learning objective was broken down to a set of skills and these were further divided into basic components.

*E.g. Sit down at a table in a café*

1. *Understand instruction*
2. *Navigate to table*
3. *Click on table to sit down*

In each testing session the interactions between the tester and the support worker were observed and certain behaviours were monitored for each component. Example behaviours are; who makes the decisions, who takes control and how much help the tester requires to do each task. A 5 point scale was produced to record the level of support worker involvement in the task, the scale ranges from no support worker involvement to support worker does task for tester, with three additional prompts: visual, verbal and physical. This allowed the change in support worker involvement over time to be monitored and any change in behaviour linked to specific components of tasks. The methodology allowed us to compare performance, behaviour and attitude. This meant any (potentially important) changes may be noticed e.g. increased involvement in and awareness of shopping in the real world or an increased confidence in performing certain tasks.

One example from the Virtual Supermarket exemplifies transfer of skill. A tester learnt to do task 2 (collect shopping trolley) alone in the VLE. Less support worker prompts were recorded in the second real world session as can be seen in Table 5a. Her support worker commented *"The testers' life skills regarding collecting and returning the trolley when out shopping have noticeably improved since the beginning of the virtual supermarket programme."* One tester used the café VLE to learn which toilet they should use in a public situation. In the first real world session she tried to enter the female toilets, but the VLE is used to put across the concept that her wheelchair will not fit in here and she must use a toilet designed with wheelchair access. This knowledge was demonstrated in the second real world session when the support worker commented "*She recognised straight away the correct sign for the disabled toilet"*. Table 6 shows the support worker involvement in this selection task.

Using the Virtual Transport facilitated the first formal 'travel training' for this set of testers. All of the testers appeared more familiar and confident in doing the tasks in the second real world session after having practised in the VLE. One tester learned to put the coins in the correct slot on the bus in the VLE and repeated this skill in the real world second session. The support worker involvement in this task can be seen in Table 5c. Another tester needed no prompts to collect the bus ticket in the real world second session, a procedure learnt in the VLE. Their support worker commented that he felt more comfortable with taking students out to cross roads and use public transport after they had trained using the transport VLE.

The results show definite examples of user skill transfer from VLE to the real world in only a handful of activities. There may have been many more, less obvious skill/knowledge development in using the VLEs which went undetected. Moreover, skills learnt during these testing sessions may not be evident in real world activities immediately but may be noticed by support workers at a later date. The investigation did not allow time to find out the optimal number of VLE training sessions for skill learning. It is possible that using the VLE over a longer training period may have allowed greater skill learning and transfer. Some testers demonstrated no obvious skill learning or transfer of skills. These testers could already successfully carry out the activities in the real world. As the evaluation study concentrated on the main learning objectives for each component, they did not allow testers to practice more complex skills.

Expert and user review methods indicate that the VLEs are seen to be representative of real world tasks and that users are able to learn some basic skills. However, it would be unrealistic to expect transfer of skill over a short time period of learning as used in this project. Using the VLE over a longer period may have allowed greater skill learning and real world transfer. Further testing is needed to establish the longitudinal learning effects and to find out the optimal number of VLE training sessions for skill learning.
Most of the evidence collected from testers was from questionnaire answers, often interpreted by a support worker. This study found the need for further development to allow users to express their views by themselves. This may involve the development of multimedia/animation based questionnaires which would allow enjoyable tasks to be completed independently by testers.

## 8. Review and Modification of the Virtual Learning Environments

The results from the evaluation study were used to critically review each of the VLE components in the Virtual City. Specific problems for each VLE were identified and recommendations for design modifications were made and implemented.

Some problems were common to all the VLEs. Generally these related to on-screen text being too small and inaccessible to the users. It was recommended that Makaton symbols replaced text wherever possible. It was also recommended that common features such as 'yes', 'no' responses and icons to move on through the VLE were standardised. This was achieved using consistent colourcoding with Makaton symbols (e.g. green for 'yes', red for 'no' and an arrow for 'move forward').

Other comments indicated that the VLEs did not provide enough, or the same cues as in the real world. One example was the scenario for paying in the Supermarket and Cafe. The original screens did not offer the same cues as the real world (see figure 9), when a coin was chosen this was illustrated by a small numeral beside the coin. The improved VLE attempts to do this by allowing the user to select a coin, which will then appear in a representation of their hand (Figure 10). They may then count the sum of selected coins, shown in their hand, before re-selection or paying with an appropriate amount of money.

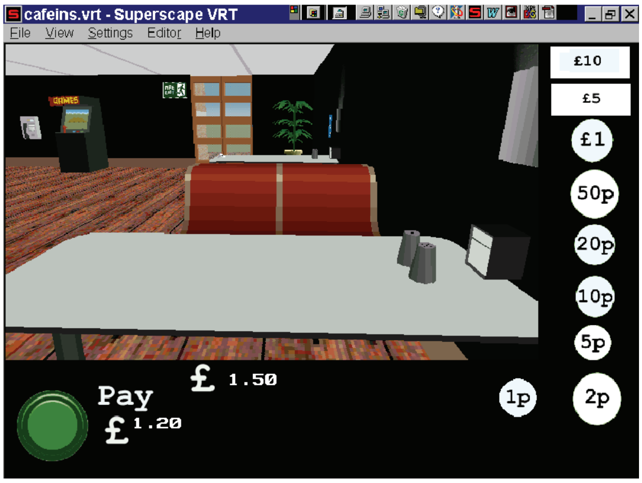


*Figure 9. First design of the payment system*


*Figure 10. Modified payment system*

## 9. Conclusions

In the first phase of development, the Virtual Life Skills project has produced a learning package of four components within a Virtual City, to teach independent living skills to people with a learning disability. Its production has focused on users' needs and representatives from the learning disabled community have represented the rights, aspirations and input of users in all stages of its development, testing and refinement. People with a learning disability have had the opportunity to develop and test a product which they will use with professionals as part of their development. The success of involving representative users at all stages of development of the Virtual City has resulted in useful and usable VLEs as well as benefiting the individuals involved in the project.

This project found that VLEs can provide interesting, motivating learning environments, which are accessible to users with special needs. Individual differences determined how much support testers required to use the VE input devices and achieve task objectives in the VLE. However, people at all levels of ability seemed to be able to access the programme. Allowing people with a learning disability to access independently the same information and instructions as able-bodied people. In the real world they are directed and prompted even if they do not want to be, in VLE they are directed using the same medium as all users. This in itself creates a sense of equality, but more so has an immediate boost of confidence in people with a learning disability.

These Virtual Learning Environments empower people with a learning disability to learn in a new way as they:

- Learn things at their own pace
- Have repetitive opportunities to learn particular life skills which are addressed in the Virtual City
- Learn by experience in a representative context– people with a learning disability seem to automatically make the connection between scenarios in the VE and the real world.
- Learn by making mistakes – within the safe environment of the VLE the user can practice particular skills as often as possible which enables them to improve existing skills or learn new ones.

Furthermore, they encourage self-directed activity in people with a learning disability- the user has to make choices within the environment to move through the VLE successfully. This in itself provides an indication of their understanding of tasks and instructions allowing observers to assess individual progress of particular users. This is something which is very difficult to achieve when other educational methods are used.

People with a learning disability do not seem to have some of the fears or phobias about computers that many able-bodied people have. In observing professional workers using VLEs often get lost or stuck and have anxieties that they have "broken it". This frequently resulted in them abandoning the session or seeking intervention. When people with a learning disability have used the VLE they seem to understand the concept of the program and the use of the input devices and do not seem to experience the problems that the professional users have.

This was verified by the change in support worker opinions during the testing period. Questionnaire responses suggested that they gained a more positive attitude towards the use of VR in teaching life skills. This was also demonstrated by the expert testers of the Virtual House who thought the technology would be suitable for teaching a multitude of topics. Twenty-eight different additional activities were suggested for just one component of the Virtual City.

An important outcome of this project is that it has enabled development of a unique evaluation methodology using a user-centred design and evaluation approach. This approach gave VE designers an opportunity to see their product in use and to identify new design criteria directly from users. The testing programme uncovered a number of usability issues of VLEs used in special needs applications. Many usability problems had common causes and the Usability Content Analysis in figure 3 shows their categorisation. Design refinements were suggested for each usability category and made to the VLEs. Further research would aim to provide design guidelines for the building of VLEs for special needs applications to decrease time to final product and minimise difficulties with usability.

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