Evaluation of virtual learning environments

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ABSTRACT

The Virtual Life Skills project describes a user-centred design approach to building virtual environments intended to provide a practice arena for skill learning in children and adults with learning disabilities. In the first year of the project four modules of a Virtual City have been developed: a house, a supermarket, a café and a transport system (see Brown et al, this issue for a description of the project). Evaluation of the project has been concerned as much with the design of the virtual learning environments (VLEs) and issues of usability and access as with monitoring skill learning and transfer to the real world. Two approaches were taken to the evaluation the four virtual learning environments. 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. However, 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 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. Further testing is needed to establish the longitudinal learning effects and to develop more reliable techniques to allow users to express their own opinions by themselves.

1 INTRODUCTION

The aim of the Virtual Life Skills Project was to develop a virtual city containing a variety of real world settings to enable individuals with learning disabilities to learn about and practise important living skills with an ultimate goal of preparation for independent living. Four components of the Virtual City were completed: Virtual Supermarket; Virtual Café; Virtual House and Transport System. These are referred to as Virtual Learning Environments (VLEs).

The project as a whole implemented a user centred approach to design and evaluation of the VLEs. Design specifications for the VLEs were made according to the User Group requirements and learning objectives defined by the project Steering Group (full details are given in Brown et al, this issue). When completed, a programme of testing was carried out to assess the suitability of the VLEs for their intended users. The results produced recommendations for design changes to each of the VLEs.

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.

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 scale 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.

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. We have identified four desirable outcomes of a VLE (Brown et al,1998):

- 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

2 EXPERIMENTAL STUDY

Figure 1 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.

2.1 Selection of Testers

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 and 20 testers were selected for the experimental evaluation study.

Figure 2 shows the range and background of testers who took part in the Virtual House evaluation study. This covered representative user population and expert representatives from the learning disabilities community.

2.2 Method

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 1 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.

2.3 Enjoyment and Usability

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 felt 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".

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 1,2 & 3. 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.

Table 1. *Expert review of Usability for themselves*

	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. *Expert review of Usability on behalf of users*

	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. *Users review of Usability for themselves*

	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

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.

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 figure 3). The categories summarise the type of problem and display the number 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.

Many usability problems of the same type occur in these three VLE's. The most frequent types of usability problems were reading text (10 incidences) and the VLE not providing enough/ the same clues as the real world (7). One main recommendation made was for standard design features (e.g. green for yes, red for no, a move forward arrow) and use of Makaton symbols in place of text. This method was used to advise and give evidence for important design modifications.

2.4 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. 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 which could be used to record the level of support worker involvement in the task, the scale ranges from no support worker involvement to physical prompts given by support worker and support worker does task for tester. 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.

The results show definite examples in tester skill transfer from VLE to real world in only a handful of activities. There may have been many more, less obvious skill/knowledge development from using the VLEs but they have gone undetected. Skills learnt from these sessions may not be evident in the real world straight away but noticed by support workers at a later date.

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. 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.

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. 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.

3 CONCLUSIONS

This project found that VLEs can provide interesting, motivating learning environments, which are accessible to users with special needs. However, individual differences determined how much support testers required to use the VE input devices and achieve task objectives in the VLE.

The reported opinions of support workers changed over 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. 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.

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 needs further development to allow users to express their views by themselves. This may involve a multimedia/animation based questionnaire.

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4 REFERENCES

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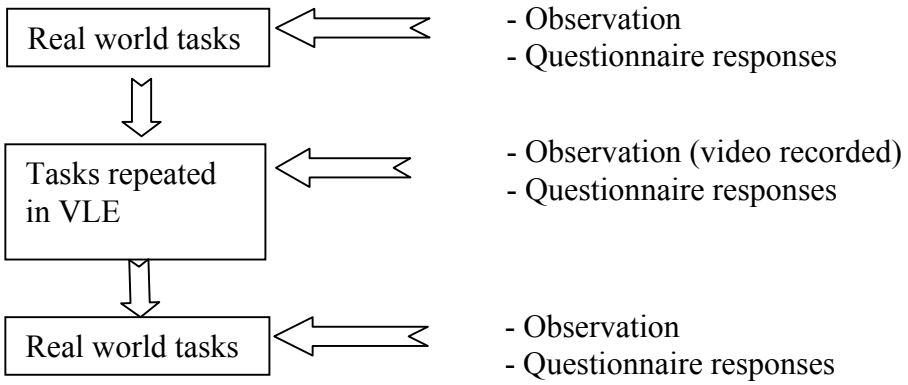
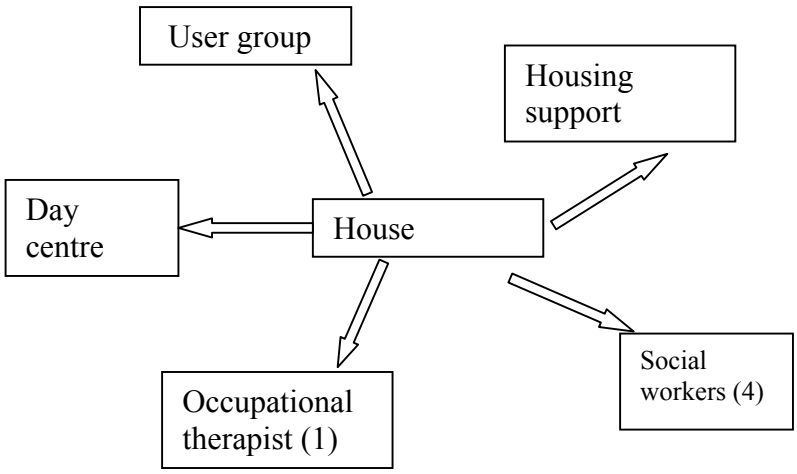


Figure 1. *Test re-test method*

Figure 2. (below) *Evaluators of the Virtual House*



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

Figure 3. *Usability Content Analysis*