

DESIGN OF A VIRTUAL LEARNING ENVIRONMENT FOR STUDENTS WITH SPECIAL NEEDS

Martin Maguire

*Ergonomics and Safety Research Institute
Loughborough University, UK*

Edward Elton

*Ergonomics and Safety Research Institute
Loughborough University, UK*

Zaheer Osman

*Active Ergonomics, Orangebox
Hengoed, UK*

Colette Nicolle

*Ergonomics and Safety Research Institute
Loughborough University, UK*

Abstract: *The European Social Fund-supported Portland Partnership project developed a computer-based virtual learning environment (VLE) to benefit students with cognitive and physical disabilities. This system provided students with access to a suite of software programs to teach them basic/essential skills needed for everyday life and to use information and communications technology (ICT). The VLE can be customized to meet individual students' needs by selecting an input device, adjusting its setting, or choosing a symbol set to support on-screen text. The learning programs within the VLE required careful design to make them stimulating and beneficial to students who have diverse health conditions and disabilities. The VLE and learning programs were evaluated within four partner Colleges of Further Education. Observations showed that students enjoyed the learning tools and the tutor comments indicated that students also benefited from them. A series of guidelines were identified for the design of future VLEs and learning software for students with special needs.*

Keywords: *virtual learning environment, learning programs, special needs, physical and cognitive disabilities, human-computer interaction.*

INTRODUCTION

Students with severe disabilities and special needs may suffer from a wide range of communication and learning impairments. A physical disability such as cerebral palsy or muscular dystrophy can affect a student's ability to form words. A cognitive disability such as autism affects the way a person communicates and relates to others around them. Students with down's syndrome may have multiple disabilities affecting both their thinking processes

and their ability to vocalize. The use of speech by these students may be limited and verbal utterances are likely to be supplemented by gestures, facial expressions, and pointing. Such students are often unable to read and may work with special symbols.

Symbols have been used for many years by people who have communication difficulties to improve their access to information and as a means of supporting conversation. Symbols differ from pictures in that each symbol represents a single concept. Two examples (see Figure 1) of these symbolic systems are the Widgit Rebus Symbols, currently containing 7,000 items covering a vocabulary of over 20,000 words (Widget Software, n.d.), and Mayer-Johnson's Pictorial Communication System (PCS), containing 10,000 items (Mayer-Johnson, n.d.).

Examples of learners (using pseudonyms) addressed by this paper include Jenny, an 18-year-old student who has cerebral palsy and limited verbal communication. She is at the Pre-entry level of learning (see the Appendix). She also uses a wheelchair. She is nervous about computers and has little experience with them. She uses a large button (called a switch; see later section, Switches and Assistive Technology) to operate a program on a computer but will not look at the screen. Chris is 21, has autism, and often lapses into nonverbal communication. He can use a switch to control a computer and has become an enthusiastic computer user. He is at the Entry 1 level of learning. Mark is an 18-year-old student with down's syndrome. He can communicate quite well, can use a mouse, and has a good deal of experience with computers, since he has one at home. He is at the Entry 2 level of learning.

For students such as these, learning is at a basic level and so, as young people and adults working at the eight Pre-entry milestones of the UK Adult Core Curricula, they are taught basic/essential skills in literacy, numeracy, and communication, as well as skills for daily life, such as washing, dressing, and cooking. Students who are a little more advanced are at the Entry 1 and 2 levels, with the broader aims of building their literacy and numeracy skills, increasing their level of independence, and possibly taking up some form of employment. The Appendix summarizes the framework for the UK Adult Core Curricula for learning literacy and numeracy for adults with learning difficulties and/or physical disabilities addressed by this paper. The complete documents for the Pre-entry Adult curriculum in the UK are published jointly by the Department for Education and Skills and the Learning and Skills Development Agency (DfES & LSDA, 2002).

Computer-based programs can support teaching by offering cognitively and physically challenged learners stimulating activities, staged learning appropriate for their ages and cognitive levels, and resources enabling them to work creatively. The use of facilities such as the Web and e-mail, which mainstream students use all the time, also increases their self-esteem. While stand-alone computer-based learning programs have been around for a long time, integrating them into a virtual learning environment (VLE) offers significant advantages.



Figure 1. Examples of PCS and Rebus symbols.

Stiles (2005, ¶ 5) describes VLEs as “on-line systems that provide collaborative interaction between tutors and students, and between students as peers, while also providing asynchronous learning resources for individualized use by students at any time.” Students will normally access the system using an ID and password. Once connected, they can communicate with their tutors and peers, view their timetable and course materials, work on projects in small groups, and access wider reference materials. A VLE can support the specific needs of students in terms of how the learning programs are presented and controlled. For example, voice output may be introduced to read aloud instructions for the student, or scanning options can be selected for switch users. The VLE may also be flexible enough to allow installation of various learning programs from different suppliers.

This paper reports on the work of the European Social Fund’s (ESF) Portland Partnership project (2005), which developed a computer-based VLE to support learners with severe learning and communication disabilities. The specific aims of the Portland Partnership are

- to develop a VLE and learning content to help students (or “beneficiaries” in ESF terms) develop skills in computer use, such as understanding cause and effect, navigation through software, and mouse functions (e.g., click and rollover);
- to give learners a greater degree of autonomy in terms of logging in, interaction with a personal computer (PC), and e-mail;
- to provide access for any learner, irrespective of the severity of his/her physical and/or cognitive disability, to the national framework for basic/essential social and self-care skills and to encourage learner progress through clearly structured and optimally accessible tools and materials; and
- to provide appropriate materials to help learners at the Pre-Entry level and above develop the relevant skills that may provide greater access to employment.

The project, which was a collaborative activity between partner organizations, was coordinated by Portland College in Nottinghamshire, a day and residential college that specializes in teaching students with physical and/or learning difficulties. Three Colleges of Further Education—West Nottinghamshire College, North Nottinghamshire College, and Chesterfield College—acted as test beds for the VLE, along with Portland College. The VLE itself was produced by Teesside University, while the learning materials were created by the Cambridge Training and Development Limited (CTAD). Two universities, Nottingham Trent University and the University of Nottingham, jointly developed a prototype wireless switch input device for students to use (described in a later section). The role of the authors’ organization, the Ergonomics and Safety Research Institute (ESRI), at Loughborough University, was to perform a user-based evaluation of the VLE and learning programs within the four test bed colleges (Portland, West Nottinghamshire, North Nottinghamshire, and Chesterfield). This paper reports on the evaluation work carried out by ESRI and the results obtained. The study involved students with a wide range of physical and cognitive disabilities who are attending ICT classes in the colleges.

The next section provides a literature review on VLE accessibility and usability. This is followed by a description of the method employed to evaluate the VLE and learning programs and the results obtained. From the results, a range of design guidelines are identified for the design of interactive learning tools for students with complex disabilities. This is followed by a sample of tutor comments illustrating students’ progress after using the learning tools developed within the project. The paper concludes with an overview of the main findings from the study and ideas proposed for future learning program enhancements.

VLE DESIGN AND EVALUATION PRINCIPLES

VLEs are now widely used to support learning within further and higher education institutions¹ (Dunn, 2003). This has stimulated research in the area of designing such systems for users with special needs. The focus of this literature review is therefore on the design of VLEs and teaching materials for students with severe physical and/or cognitive disabilities that affect both their communication and learning processes.

Accessibility Issues

Accessibility is the ability of a product or system to be perceived and used by people with the widest range of capabilities. To support accessibility, the system should be flexible so that it can be adapted to people with specific needs. For example, it may allow the text size and contrast between the text and background to be increased to meet the needs of users with visual impairments. Accessible systems also allow a connection to assistive technology for disabled users, such as a screen reader, speech input device, or switches for users who require a very simple method of input. (For more information see Gill, 2004, 2006; the World Wide Web Consortium's Web Accessibility Initiative [W3C-WAI], 2005; the legislative requirements of Section 508, enacted in 1998, of the United States Rehabilitation Act, n.d.; and the mandatory accessibility of learning materials in the UK, enacted by the Special Educational Needs and Disability Act [SENDA], 2001.)

Stiles (2005) conducted a study to record problems encountered by disabled students of two VLEs and then identified possible solutions. Stiles found that navigating a VLE posed the most problems. He suggested a number of guidelines for designing accessible navigation, many of which are based on the W3C's Web Content Accessibility Guidelines (W3C-WAI, 2006b). A few of the example guidelines, from Stiles (2005, section 5.1.1), relevant to students with special needs are presented here:

- Make it easy for the user to control the "focus" of the screen, that is, the part that is currently active (highlighted by the cursor) and to ensure that this is in sync with the assistive software providing audio support.
- Keyboard equivalents for all menus and menu options must be provided.
- Keyboard accelerators (shortcuts) should be available where tabbing becomes excessive.
- Allow the user (tutor or learner) of the VLE to override settings, such as font style, size, and color, and the background color of the screen, possibly through Cascading Style Sheets (CSS).
- The use of icons must be accompanied by textual information or alternative text that can be accessed via screen reading software.
- Ensure that, in addition to the VLE, the learning content within it is also accessible.

The EU's World Wide Augmentative and Alternative Communication project (WWAAC, n.d.) developed an adapted Web browser tailored to the needs of users with complex communication and/or cognitive impairments. It also developed a communication infrastructure and protocol to support symbol-based communication based on concept coding that is used by many Augmentative and Alternative Communication (AAC) users. An example of the WWAAC browser screen showing simplified command icons and links to predefined user favorites pages is shown in Figure 2.

The WWAAC project evaluated their adapted browser with users with positive results. The users' experiences were affected however by external factors, such as the browser leading to poorly designed Web sites (a problem also found by Stiles), and technical problems, particularly with the scanning process for switch input devices. The project concluded that Web developers and designers should be provided with guidelines and standards for accessible design for people with a range of communication disabilities. Practical accessibility guidelines for Web masters have been suggested by the WWAAC project, based on the project's user requirements and evaluation work (Poulson & Nicolle, 2004). These guidelines have been fed into the W3C's WCAG Working Group (W3C-WAI, 2006a) and can be found on the WWACC project website (WWAAC, n.d.).

While accessibility for a wide range of users is an important requirement, this may be difficult to achieve. As Techdis (n.d.a, ¶1) states, "Accessibility is often a balance between contrary tensions. A text-based resource accessible to screen readers [for users with visual impairments] may be inaccessible to a dyslexic learner, a deaf learner or somebody with cognitive difficulties." Techdis (n.d.b) further emphasizes that "Providing responsive pedagogical solutions is often more important and effective than making something 'technically accessible' [to a screen reader]" (Personal reflections section, ¶1). In terms of accessibility then, Pre-entry learners with severe physical and/or cognitive disabilities require facilities that match their particular capabilities and needs, such as bright animated content with speech output, together with very simple methods of input and navigation.



Figure 2. WWAAC project browser screen showing a Favorites page.

Usability Issues

Usability is concerned with the ability of the users to understand the system, navigate through it, and achieve tasks with few errors. According to authors such as Dix, Finlay, Abowd, and Beale (2003), Nielsen (1994), and Rogers, Sharp, and Preece (2002), a usable design should be

- simple and intuitive
- consistent with conventions or standards
- flexible and efficient
- clear in prompting and giving feedback
- helpful to the user in avoiding errors as well as supporting error recovery.

Dunn (2003) conducted a study aimed principally at people involved with the implementation of VLEs in further and higher education institutions. She conducted six interviews with educational specialists within UK universities and a college of higher education, had email exchanges with experts in the field, and performed an online survey of users of academic mailing lists run by the Joint Information Systems Committee, gathering 46 responses. Many respondents commented on the difficulty that users with disabilities had in using a VLE, even if it was technically accessible. Problems included too many windows, poor keystroke navigation, and unclear help messages. Dunn also found that learner competencies may be overestimated by both tutors and the learners themselves. Assessment and support strategies are needed to address these issues, otherwise this could lead to a reduced quality of learning experience, loss of confidence, and a reluctance to engage in further learning experiences via the VLE by students with disabilities.

Barnes and Walter (2000) provide advice on designing Web pages for people with learning and communication difficulties that could be applied to VLEs and to learning software in general. They propose using large clear buttons that incorporate icons as well as text. They also suggest using consistent and clear page layouts, avoiding complex backgrounds (a simple white background is sufficient), avoiding the use of scrolling pages, providing symbol support for plain text, and placing navigation controls in a consistent place on the screen. These guidelines have been applied to the Portland Partnership VLE and the learning software to make them as usable as possible.

Personalization

Personalization of software allows it to be customized to the user's requirements and preferences, initiated either by the user or by the computer. A fundamental limitation of e-learning systems is that they give students little opportunity to influence and manage their learning activities (e.g., control the order of learning, tailor the problems to their own situations), which are important for knowledge construction (Martinez, 2002). For students with learning and communication disabilities, it is important for the system to be adapted to their specific needs, such as their choice of input device or symbol set. It is also desirable to allow the students to make choices about which learning programs they use. In the Portland Partnership work, an important element was the ability to tailor the software inputs and outputs to the needs of the individual users. Consideration was also given to allowing residential students and students staying after normal teaching hours to choose which learning activity they would undertake in the evening and to record it on their VLE timetable.

Multimedia and Multimodal Techniques

There is much evidence to support the benefits of using of multimedia and multimodal interfaces for students with communication and learning disabilities. Itoh (2002), for instance, reports that people with autism have good visual information processing skills and that AAC systems with graphic symbols have been used successfully with autistic children at special schools. In the Portland Partnership, the programs were visual in nature and symbols were used for activities such as login and navigation. Schlosser, Belfiore, Nigam, Blischak, and Hetzroni (1995) have shown that speech output communication devices facilitate graphic symbol learning, while Burkhart (2002) found that multimodality (e.g., mouse and switch input with audio, text, and graphic output) can support children with autism by enhancing receptive understanding, cognitive processing, and expressive language; reducing frustration; and improving behavior.

Switches and Assistive Technology

Many users with physical or cognitive/learning impairments have to use a switch rather than a keyboard or mouse to interact with software. A switch is a simple button used with software that presents a scanning rectangle on the screen. The user presses the switch when the rectangle is located on the selectable item they want, such as a menu option, picture, or on-screen button. This may then lead to more options to select in continuing the interaction. Usually the rectangle moves automatically (autoscans) with a single switch used for selection. Alternatively, the user may operate two switches—one to tab between items on screen and another to make the selection. The first method is the most efficient for users who have developed good timing skills and it should be possible to change the scan speed to suit the user. Two switch scanning gives more control to the user but demands physical access to, and reliable control of, both switches (Colven & Lysley, 2001). Figure 3 shows a pair of switches that can be linked to a PC.

Within the Portland Partnership, Nottingham Trent University and the University of Nottingham developed a prototype wireless switch (Brown, Battersby, Standen, & Anderton, in press) making it more convenient for a student to use the VLE, particularly in conjunction with other assistive technologies that they may require. The switch can store information about the student, which is then communicated to the VLE so that the system can be customized to meet his/her cognitive and physical needs. Potentially the switch could contain the user's login details



Figure 3. Switches with a PC interface box.

for the VLE, preferred scan speed, text size, screen colors, and so forth. A simple game program was developed by the same partners to test the user's responsiveness so that the scan speed of the switch could be adapted to the current physical state of the student and his/her level of alertness or fatigue.

Another issue is how well the communication aids that disabled students may use for everyday communication fit in with the PC they use to access the VLE and the learning programs. Students with complex communication problems may need to use a speech synthesizer with a special keypad, or special switches attached to their wheelchair, to communicate with others. Users with such needs therefore require that their communication aid is compatible with the VLE computer and that they can physically reach the system (Poulson & Nicolle, 2004).

Curriculum Basis and Progression

Sturm (2002) emphasizes the importance of relating learning programs for special needs to the curriculum for the students. She states, "A solid understanding of grade level curricular demands, literacy activities, and materials used will allow school support teams to consider individual learning needs and develop appropriate activities" (p. 1). A progressive curriculum for both schools and adult education may be based around a framework such as

- switch access
- passive stimulus (e.g., video sequences)
- cause and effect, and coordination
- pre-academics (e.g., choice making, matching, sorting, life skills)
- academics (i.e., numeracy and literacy skills).

The Portland Partnership produced learning software within a similar framework for students at the Pre-entry and Entry levels.

Evaluation of Systems with Special Needs Users

Useful guidelines for running user evaluations with special needs students are offered by Heim, Endestad, Skjetne, Maguire, and Vereker (1998). They state that it is important that a user with cognitive impairments feels safe and secure and therefore should be accompanied by someone he/she knows, such as a tutor or assistant (caregiver). The evaluator may interact with the student, with or without the tutor assisting, or be present in the background. The aim of the test must be clearly and simply stated to put the user at ease.

Students with cognitive impairments prefer to learn new things slowly, in a step-by-step fashion. Therefore, they should be given enough time to complete each program and to overcome any problems that arise. It is important not to put too much pressure on users to complete the tasks, and to provide support when needed. For students with physical impairments it is necessary to consider whether the physical arrangement of the desk and chair is suited to the user, and whether users in wheelchairs can reach the input device, particularly if they have communication aids or other devices attached to their wheelchair.

The user should be assessed to determine the most suitable input device for him/her. These input devices include, for example, a mouse, single switch, dual switch, or large keyboard. The student's preference for input device should also be considered. For both

cognitively and physically impaired students, each user session should be kept short to prevent the students from becoming tired and losing concentration. In addition, having shorter sessions enables several students to take part during the same classroom period.

In order to capture user assessments of learning software from users with cognitive impairments, a simplified rating scale is needed. Murphy (1998) developed a low-tech tool called Talking Mats to assist in communicating with AAC users. Three sets of picture symbols representing issues, emotions, and influences were arranged on a textured mat to create a composite picture of what was meant. The Talking Mats are intended to supplement a person's means of communication rather than replace his/her communication aid or use of facial expression and gesture. In Murphy's (1998) study, the Talking Mats were used with people with cerebral palsy and expressive dysphasia. This idea was also used within the WWAAC project to gather user attitude data as reported in the user evaluation plan (Nicolle, et al., 2004). A similar type of smiley scale was used successfully in the Portland Partnership project, as described in the Evaluation Method section of this paper.

VLE and Content Design

The main focus of the development team was to produce a VLE with learning content accessible to learners from the earliest milestones of the Pre-entry level to Entry Levels 1 and 2 (the Portland Partnership target user group). The problem with many commercial VLEs, however, is that they are pitched at too high a cognitive level and often lack the accessibility features that learners in this group require. The Portland Partnership VLE was therefore designed to focus on the needs of learners with severe cognitive and communication disabilities, that is, to be primarily graphical and audio-based rather text-based, as many of these students respond best to pictures and sounds and are also non-readers. Macromedia Flash and an audio/visual interface were employed to be attractive to Pre-entry learners. The VLE components were supported with symbols, graphics, and audio and speech output to enhance on-screen instructions. The environment could also be customized for individual student's needs, such as an adjustable switch scan speed and the choice of symbol set (PCS or Rebus). The learning materials produced by the Portland Partnership enabled students to develop basic/essential self-care skills and ICT skills simultaneously. As the VLE was aimed primarily at a Pre-entry level, age-appropriate and accessible materials were designed to augment existing learning resources, to reinforce good learning practices, and to help develop skills, such as an awareness of cause and effect, navigation through software, and basic literacy and numeracy. Further details of the VLE and learning materials are provided within the Evaluation Results section of this paper.

EVALUATION METHOD

The Portland Partnership developed its own learning programs and VLE, each of which was evaluated by the authors of this paper in conjunction with the tutors and students in the partner colleges. The method adopted for the evaluation is described below.

Evaluation Aim and Objectives

The main aim of the evaluation was to test the Portland Partnership's software-based learning programs and VLE with a wide range of students with communication difficulties caused by severe cognitive and physical disabilities. The supporting objectives were to

- evaluate the effectiveness of each program or VLE element by making observations of its use by students and recording tutor comments;
- draw out specific recommendations for improving the programs; and
- identify general guidelines for designing learning programs and VLEs for students with cognitive and physical disabilities.

Participants

Initial meetings took place with the tutors at each of the partner colleges in November 2004 to discuss plans for the evaluation and inquire about the various students who could participate. These meetings helped provide profiles of the user subjects, and to discuss the ICT equipment required. Participants were recruited from the Colleges of Further Education within the project (North Nottinghamshire College, West Nottinghamshire College, and Chesterfield College) and the specialist Portland College. Since the students needed to remain within the normal classroom setting supported by tutors or assistants, it was decided to run the evaluation sessions during the periods that the students had ICT lessons. This minimized the disruption to the college timetables.

Student Sample Profile

Across the four colleges, a total of 27 students participated in the evaluation. As Table 1 shows, these students have a wide range of medical conditions (some having multiple conditions) that significantly affect their physical, sensory, and cognitive abilities.

Of the users, 20 are male and 7 are female, and aged between 18 and 24 years, with the exception of one male student who was 54. Regarding input devices, 18 were mouse users, 8 were switch users, and one was a joystick user. In terms of educational level, 18 of the students were at Pre-entry level, while 9 were at Entry 1 or Entry 2 level. Approximately half of the students (14) are wheelchair users. In terms of computer use, 8 were fairly familiar with using computers (within the limits of their capabilities), 12 had some experience in computer use, while 7 had little experience. The majority (17) said they were "enthusiastic" about using computers, while the others were less so.

Informed Consent

It was necessary for each student, or his/her parent or caregiver, to agree to participate in the VLE evaluation trials and to sign an informed consent form. The decision to participate was jointly agreed to by the student and parent. The student then signed the consent form if he/she was able. Otherwise it was signed on his/her behalf by the parent or caregiver. It was later decided within the project that informed consent would be obtained for all project-related user trials as part of a single process.

Table 1. Conditions Represented in User Sample Within the Evaluation.

Condition	Physical	Sensory	Cognitive	Number of students in sample affected
Autism		✓	✓	1
Autism and nonverbal communication		✓	✓	1
Cerebellar hypoplasia	✓			1
Cerebral palsy	✓			1
Cerebral palsy & severe learning difficulties	✓		✓	4
Cerebral palsy and limited or nonverbal communication	✓		✓	4
Cerebral palsy, sclerosis of spine & global developmental delay	✓		✓	1
Down's syndrome	✓	✓	✓	3
Down's syndrome, limited verbal communication and registered blind	✓	✓	✓	1
Dyslexia and learning difficulties			✓	1
Global developmental delay			✓	1
Hemiplegia & auditory defensiveness	✓	✓		1
Leigh's encephalopathy	✓	✓	✓	1
Memory loss (short & long term)			✓	1
Physical injury	✓			1
Soto's syndrome	✓		✓	1
Spina bifida & hydrocephalus	✓		✓	1
Wolf-Hirschhorn syndrome	✓		✓	1
Worster-Drought syndrome	✓			1

Evaluation Tools

A checklist was developed to support the observation of the students. In addition, a rating scale was created to capture student reactions to each learning program or VLE element.

Observation Checklist

To support the evaluation of the VLE software and learning programs, a general checklist was defined regarding aspects to look for when observing students:

- ability of the program to stimulate and maintain the interest of the student;
- ability of the student to navigate and complete the program successfully;
- flexibility of the program to support the individual student's unique needs;
- types of errors made by the student in using the program;
- the time and effort needed by the student to complete the program;
- the student's level of satisfaction having used the program.

Smiley Rating Scale

A version of the smiley rating scale described in the literature review was used to gather students' ratings of satisfaction with each learning program. During a pilot evaluation of the early prototypes, it was found that a 5-point scale could be used successfully. To elicit user responses, the students were shown the smiley scale. The facial expressions on the scale were made distinct in order for the students to easily differentiate them when giving a rating (see Figure 4).

It was thought that the scale could be presented to each student either on the screen of a laptop computer or on a laminated card. It was found to be easier and more flexible to show the scale on a card and to record the ratings, together with the observation notes, on paper.



Figure 4. Smiley scale to capture student feedback.

Evaluation Procedure for Each College Visit

The VLE and learning programs were evaluated between February and May 2005, focusing on new programs as they were developed and disseminated to the colleges. Some of these were early prototypes and therefore works in progress. Access to the full VLE was also limited, as project partners were in the process of completing it and integrating the programs within it.

In general, two ESRI evaluators worked with each student, one guiding the student's use of the learning programs, the other recording observations and ratings. Occasionally one evaluator worked with the student, both guiding the session and recording observations. A tutor was also on hand to assist in communication with the student, although this was rarely necessary. The tutors advised the evaluators as to which students should try which programs, based upon their capabilities, and which programs they had not used before or only a few times (and so had not become bored with them). The evaluation was based upon a specific IT student group at each college and so some of the testing of software designed for Pre-entry milestones included feedback from students at the higher Entry levels. However this was still found to be useful. It was intended that each student would spend only a short time at the computer to give him/her a chance to try some programs but not become bored or restless. This approach meant that each student used only a portion of the programs available.

Within each session the following procedure was adopted:

- Before each session started, the tutor gave some background information about the student taking part in the trial—his/her name, age, medical condition or disability, learning level, preferred input device, and any other relevant details (e.g., “may not want to stop using the computer at the end of the session”).
- When the student came to the computer, he/she was informed by the tutor or evaluator that he/she would be using it to test some learning programs. The tutor then suggested which programs were suitable for that student's capabilities.

- The student was asked to use three or four programs per session. He/she was given a little help to get started and further help as needed. The students normally worked on each program for about 5 minutes before wanting to try another, making the session 15 to 20 minutes in length.
- While each program was being used, the evaluators made notes of their observations of the student's use of the program.
- When the student finished each program, he/she was asked to give a smiley scale rating to indicate how much he/she enjoyed using it. This seemed to work well as the students were able to point easily to the appropriate face on the scale.
- At the end of each session, the tutor gave some general comments about how well he/she felt the student had done. The tutor also commented on the programs and how they could be enhanced to better meet the student's needs.

EVALUATION RESULTS

This section presents the evaluation results for a representative sample of the learning programs and VLE facilities tested. Since the evaluation, a number of updates have been made to both the VLE and the programs by the project development partners, taking account of the results obtained.

Observations of Students

The learning programs and VLE software that were evaluated are classified into two main categories:

Learning Programs

- video stimulus
- cause and effect
- number, matching and sorting skills
- life skills
- slideshow authoring and presentation.

VLE Facilities

- VLE login
- e-mail
- tutor tools.

The observations made of students using the programs and facilities within each category are presented below. The data presented summarize the reactions of the students as a whole to each program. They describe which parts of the programs the students enjoyed as well as how well they performed, which is an especially important aspect of a successful user experience for students with severe disabilities and special needs.

Video Stimulus

A short video sequence, titled *What We Like*, showed individual students carrying out creative activities within college sessions and also attending a party. Since the video required only passive viewing, it was appropriate for most of the students. Some viewers were stimulated by recognizing fellow students in the video. Several felt that they would like to be filmed when performing a similar activity and be able to see themselves on screen. Those who did not recognize the students in the video were generally less enthusiastic.

Cause and Effect

This group of programs showed everyday scenes and activities to teach an appreciation of the concept of cause and effect. The users could click on the people and objects in the scene that were then animated using the Flash software. The programs were developed mainly for Pre-entry learners.

Fireworks. This lively program consisted of two parts. First, the user clicked on a moving rocket to make it explode. He/she then clicked on a set of planted fireworks to see a display with sound effects (see Figure 5). This appealed to all of the users and several Pre-entry students found it exciting. They liked the variations presented when clicking on the rocket to make it explode into different colors. However some of the students were unsure what to do when the first screen was displayed. One tutor suggested that the rocket and fuse could be larger or there could be a match or flame to click to start the process. For higher level learners, it was suggested that the program could include added variety, such as having several different fireworks on screen, or allowing the user to select the order in which the pyrotechnics were set off.



Figure 5. The Fireworks program.

Party. This program presented a party scene (see Figure 6) in which users could click on individual partygoers to make them dance, eat, serve drinks, and so on. Students enjoyed using this program when encouraged to click on the different characters. Wheelchair students

could identify with the girl and boy who danced in their wheelchairs. They also enjoyed seeing a person opening a door to complain about the noise. The activity was designed for the early milestones of Pre-entry level students to develop an understanding of cause and effect. Therefore, the Entry level students who used it found it slightly basic for them.



Figure 6. The Party program.

Kitchen. Students clicked on kitchen equipment items to animate them and to hear the sounds they make (see Figure 7). Each sequence included a kitchen disaster, such as toast burning, food in the microwave exploding, the washing machine leaking, or water rising in the room with a picture of a shark swimming past. The more advanced students, who appreciated that these events were fictional, enjoyed seeing things going wrong and could identify with the mishaps. However some of the students at earlier stages of learning made a more literal interpretation and became anxious when seeing the disaster elements. It was suggested therefore that a second version of the program be developed, without the disasters, for the Pre-entry students.



Figure 7. The Kitchen program.

Number, Matching and Sorting Skills

This group of programs was designed to teach number and matching skills using well established games, such as pairs, snap, and a slot machine. A program on sorting objects into groups was also included. A cinema theme program required number and matching skills to direct a visitor.

Pairs. In this game, a set of cards was displayed showing different colors to match. An upbeat chime sounded to indicate a correct selection while a downbeat sound (known in the UK as a “raspberry”) was used to indicate an incorrect selection. The students found this latter sound amusing. Some of the project staff anticipated that students might deliberately put in the wrong answer when pairing cards in order to hear it. However, this did not turn out to be a problem or prevent the students from using the program properly. In a variation of the game, the cards contained both analogue and digital times of the day to be paired off, for example, 4 o’clock on a clock face and 4:00 shown as a number. This version was seen as a good way for students to learn to tell time and was enjoyed by most of the users.

Cinema. Here a cinema setting was shown (see Figure 8). Students were given choices such as which studio to enter with their ticket (showing the studio number) and which washroom to go into afterwards (Men’s or Ladies’). This program was enjoyed by Entry level students, especially when a man who was sent into the Ladies’ washroom by mistake reappeared with a red face.

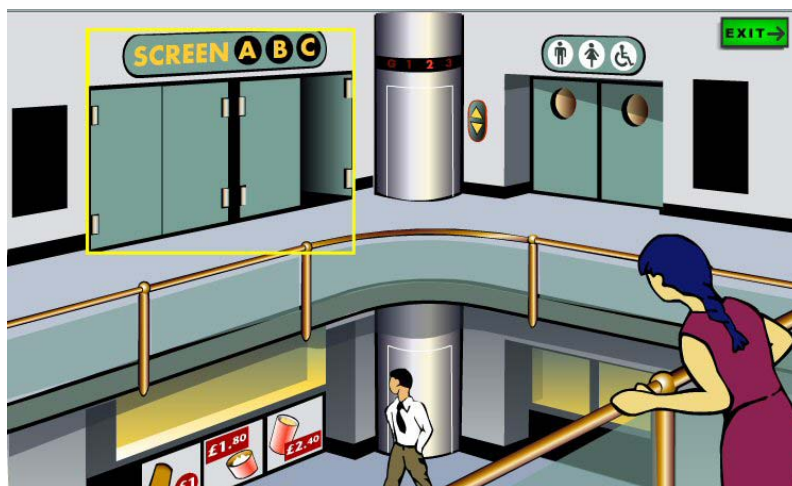


Figure 8. The Cinema program.

Sort It Out! In this program, a sequence of forks and spoons appeared above two drawers. The user was required to identify each one as it appeared and click the correct drawer to place it (see Figure 9). Most of the users liked this program. One student found a “cheat” mechanism: By clicking the mouse quickly on the item, the program automatically put the spoon or fork into the correct drawer. The auditory feedback given for either correct or incorrect selections was found useful by the students. Another student tried to drag and drop items into the draw rather than just clicking on the correct draw and so needed guidance from the evaluator.

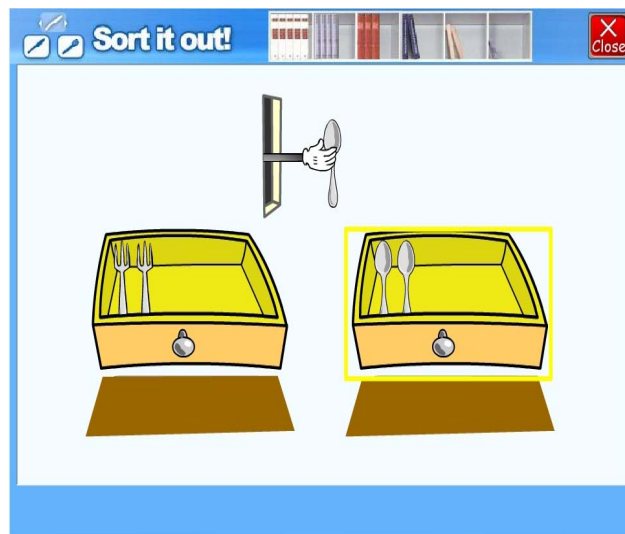


Figure 9. The Sort It Out program.

Spin. This program was based on a slot machine in which the user has to calculate the difference between two times of day randomly displayed on two reels (e.g., 9:00 and 11:00) and to “nudge” the correct time difference into place on the third reel (see Figure 10). Many of the students were familiar with slot machines and enjoyed using the program. The students who were not able to select a correct answer immediately were assisted and shown how to use their fingers to work out the difference. This led to most of the users getting the correct answer, which was a good achievement. Since *Spin* was designed for Level 3 students, it was found to be rather advanced for Pre-entry level students. It was suggested that a simpler version with fruit symbols or numbers could extend the range of users who could benefit from this program.



Figure 10. The Spin program.

Snap. In this game, two users play each other while sitting at separate PCs. Each had a virtual pack, or deck, of cards and took turns playing a card. When a pair occurred, the first player to click on the two matching cards was awarded a point. Clicking incorrectly lost a point. Entry level students enjoyed the competitive element of this program, playing against a classmate. Sometimes they found it hard to distinguish whose turn it was and the game sometimes allowed both players to either win the same “snap” or to get the wrong answer. This was not necessarily seen as a drawback by the evaluators or the tutors and it seemed to add to the fun for the students.

Life Skills

In the program on personal care, designed for Pre-entry level students, the user was shown a set of images to convey the sequence of actions in daily tasks, such as washing or cooking (see Figure 11). They were then asked simple questions to test their knowledge of the order of the actions. Students identified with the activities, which they found stimulating.



Figure 11. The Personal Care program.

Slideshow Author and Presenter

A program called Slideshow Author (a simple equivalent of Microsoft PowerPoint) was developed for creating and viewing slide presentations as part of a learning activity. This allowed the tutor to set up resources and to create slideshow templates for students to view or add to. These could then be assigned to particular learners through the VLE. The templates could be on topics of particular interest to the students, such as learning activities, home activities, college trips, or holidays. A simpler tool called Slideshow Presenter allowed students to add text, images, video, or background sounds to personalize the slideshow. They could then “play” the result back to themselves or to others. The tutors considered that these tools held a lot of potential since they allow students to be creative and to express themselves by describing their own interests and activities, or to present a story, possibly using their own photo images.

It was expected that Entry level students in particular could create their own plans as a sequence of pictures—such as making beans on toast, going to the shops, or going on holiday—and later see whether this was what happened in reality. The students could then change the sequence to match their experiences. The tools were accessed online so that resources could be shared with other classes and colleges via the VLE. The students liked to see the pictures of themselves on the computer or the work they had done incorporated within slide shows. Figure 12 shows a slideshow being developed in Slideshow Presenter by a learner of a social event, possibly using a template developed in Slideshow Author. Figure 13 shows the slideshow being played. (The actual photographs used in the slideshow have been replaced here by cartoon images.)



Figure 12. A slideshow being created by a learner in Slideshow Presenter.

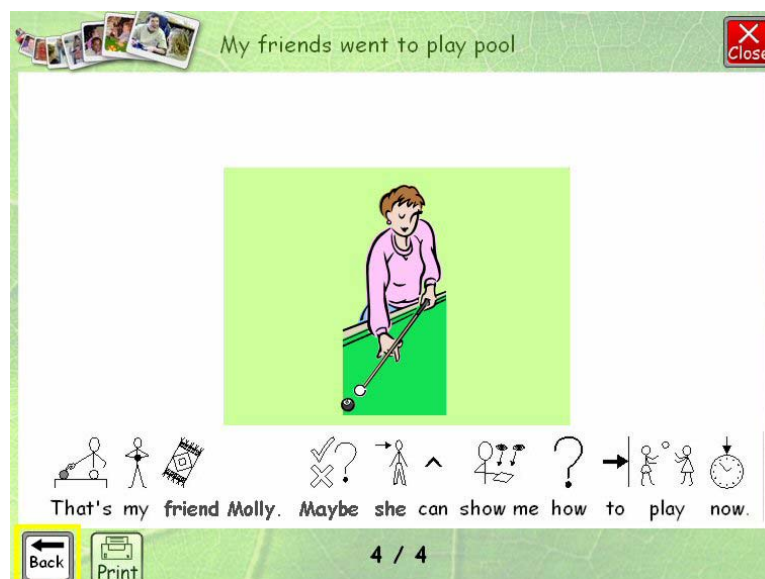


Figure 13. The slideshow with symbols incorporated being played.

The evaluators made further suggestions to improve this program, reflecting the need to adjust the capabilities for the various learning levels. Some possible additional features suggested were

- messages from tutors to make students aware of new presentations they have to view or complete;
- adding text to images to add context for some users; for example, an image of a cup could be labeled “cup of tea”; and
- an automatic slideshow Play option for students at earlier stages of learning.

The colleges within the partnership started using the tools and building up libraries of pictures (including photos taken by the students in this study and other college students) as resources for inclusion within slideshows. The system was being developed with access levels so that resources could be shared across a class, between classes, and possibly between the different colleges. Speech output for text could also be included so that sentences in a slideshow could be spoken. However this would need to fit with any additional sounds that might be selected to accompany the show. It was thought that the adaptability of the Slideshow Author and Slideshow Presenter programs meant that they could be beneficial for a wide range of students with special needs and also for primary school pupils in general.

VLE Login and Navigation

The VLE login process required the user to select three symbols in sequence from an array of nine. This process taught the students the idea of logging on to a system (see Figure 14) to

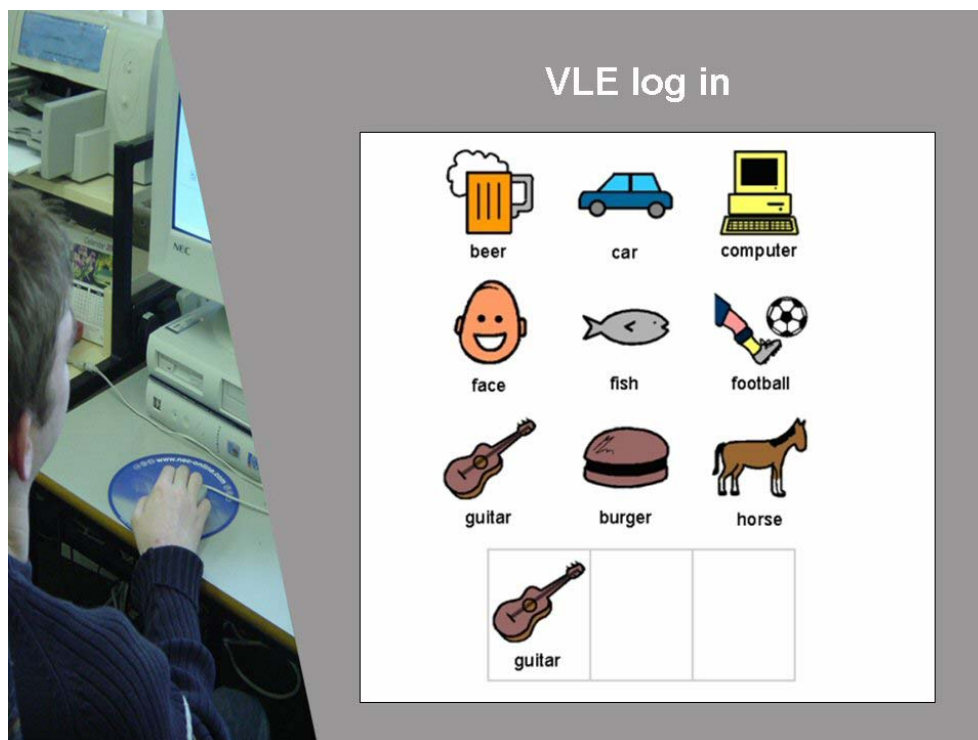


Figure 14. The Portland Partnership VLE login.

give them access to programs relevant to them. Within the VLE, speech output was used to prompt the user about what to do and to reinforce what was presented on the screen. Thus as the switch scanning rectangle passed over each login symbol, its name was read out.

Some of the users became confused when the speech output lost synchrony with the symbols; this problem was addressed in the final version of the VLE. The users had to confirm each selection of a symbol, which helped avoid errors in selecting the symbols but also made logging in a slightly lengthy process. An alternative suggestion was to provide a Delete or “start again” function if an incorrect symbol was selected. However the users were generally happy with the VLE login facility and were able to use it successfully.

After logging in, the student was presented with a main menu of text with symbols providing access to the different facilities. They could choose to open their e-mail, learning programs, or timetable programs (see Figure 15).

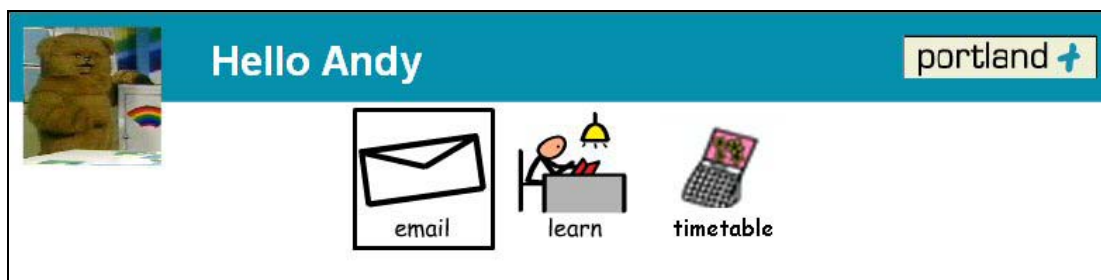


Figure 15. The Portland Partnership VLE main menu.

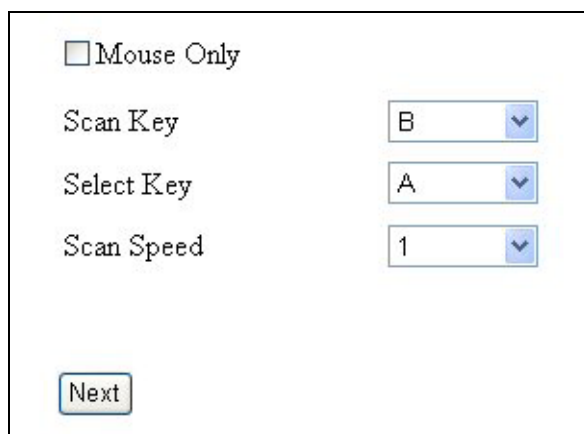
E-mail

A simple e-mail program was developed within the VLE. The user could choose either to read his/her incoming e-mails or to send an e-mail to his/her tutor or to a classmate. Students could choose the recipient from a list of names accompanied by pictures to help identify the correct one. The e-mail was composed by selecting a topic area (as the subject) and a sentence in text form, supported with symbols and speech, from a predefined list. Although this gave the students only limited options for topics and/or composition, it provided an ideal starting point for students with severe disabilities to experience e-mail communications for the first time. Using the e-mail also gave them a sense of achievement. One Entry level student preferred his e-mail to be presented in words rather than symbols, indicating a need for flexibility of display of e-mail. Some students also wanted to communicate with more flexibility and options than the fixed phrases allowed. The list of phrases could be extended by the class tutor.

Tutor Tools

When the tutor logged into the system, he/she accessed a set of VLE management tools via the main menu options: Home, Administration, Learning Materials, Features, and so on. The VLE was context based so that when a tutor logged on, he/she was given access to just the classes within his/her responsibility. In setting up access for a student, the tutor stepped through a number of stages to guide the process. Part of this was to set up each student's method of input, as shown in Figure 16.

In setting up students within the VLE, the tutor needed to be prepared with suitable pictures and audio files to personalize the students' identities within the VLE. Initial tutor reactions to the tools within the training sessions were positive. A simple user guide was also prepared by the project to support the tutors after the training.



The screenshot shows a configuration window with the following elements:

- Mouse Only
- Scan Key: B (dropdown menu)
- Select Key: A (dropdown menu)
- Scan Speed: 1 (dropdown menu)
- Next button

Figure 16. Setting up a student's input device within the Portland Partnership VLE.

Ratings by Students

Each student was asked to give a satisfaction rating for each program using the 5-point smiley scale (1 = *Likes program very much*, 2 = *Likes program moderately*, 3 = *Neither likes nor dislikes program*, 4 = *Dislikes program moderately*, 5 = *Dislikes program very much*) so the lower the value, the better the rating. They were asked to indicate a particular face on the scale (rather than choosing any point, possibly in between the faces). The learners were found to do this naturally. The average rating for the various programs was between 1.0 and 3.0 indicating that the programs were regarded positively by the students. Specifically, the learning programs received average ratings between 1.3 and 2.7, the VLE login process received a 1.7, and the e-mail program was given an average rating of 3.0.

Student Progress Using Learning Materials

By the end of the project, a wide range of learning tools had been produced. Although these had only been evaluated over a relatively short period of a few months, comments from the tutors indicated that students had benefited from them and progressed as a result. Some example tutor comments are presented below.

Pre-entry Level Switch Users

This student has become much better at using the computer. She now uses a "Big Mac" (large switch), with a recording of her own voice, as part of a group. This is a huge breakthrough. She does not yet focus on the screen but is using the cause and effect of touch equals sound. The programs have benefited this user very much.
(Student with cerebral palsy and limited verbal communication)

This student is now much more aware of the purpose of a switch and now links it with the sound it produces. We are now working on awareness of the screen. It is great that using the switch helps to involve this user much more in group activities. (Student with cerebral palsy, nonverbal communication, and restricted motor skills)

This user enjoys using all programs and they have really helped his concentration. He now chooses to use the computer—he would not use it last year. These programs will benefit this user very much. (Student with autism and nonverbal communication)

This student continues to thoroughly enjoy using the computer and it is proving to really help in developing his communication skills as well as his interactions with others. He is becoming very familiar with the programs and it would be good if he had some at the next level. (Student with communication difficulties and in a wheelchair)

This student enjoys using the computer if he likes the look of what is on the screen. His interest is quick to wander and it would be useful to have activities that continually change so to assess understanding rather than learning the routine. (Student with limited verbal communication and in wheelchair)

Entry Level Mouse Users

This student preferred the programs where he had things to do. He was amused by details and programs showing things going wrong or slightly rude scenes. [In the games programs] he wanted to drag players around [rather than simply click on them]. (Student with hemiplegia, learning difficulties, auditory defensiveness, and modulation)

Enjoyed programs generally. Liked to explore and successfully discovered hot spots. He wanted to see himself on the video. (Student with learning difficulties and Soto's syndrome)

He was generally successful and recognized other students on the video. He was able to click on items in cause and effect scenes and remember which ones he had chosen. He was able to click on the rocket at different stages to see the different colors. [In an early prototype band playing program] he wanted more band members to be animated and play their instruments. [Note: In the final version, all the band members played.] (Student with learning difficulties, spina bifida, and hydrocephalus)

A more advanced program like the Slideshow Presenter would be useful for this student. (Student with Worster-Drought syndrome and learning difficulties)

RECOMMENDED VLE DESIGN FEATURES FOR USERS

An important aim of the study was to identify features that can improve the effectiveness of learning environments in general for students with special needs (severe cognitive and

physical disabilities). The evaluation produced a number of recommendations, as listed in Table 2 and described in the following sections.

Table 2. General Recommendations for VLE Facilities and Learning Programs.

Category	Design recommendations
VLE facilities	Simple method of login tailored to individual students. Clear menu to select and launch programs.
Tutor information and control	Indication of appropriate educational level. Easy set up for individual students.
Learning program content	Student identification with learning materials. Fun elements. Variation to maintain interest. Versions to match different ability levels. Allow students to function on par with mainstream users. Games allowing for interaction or competition with classmates.
Interaction facilities	Speech output support. Exploration of on-screen elements. Design to match the range of student capabilities within the classroom. Clear and consistent switch scanning rectangle. Clear areas to click and consistent navigation.
Feedback to students	Alternatives to words and numbers. Audio/visual indications of success or failure. Certificates of completion or achievement.

VLE Facilities

Simple Method of Login Tailored to Individual Students

Symbols may be used as a means for students to login to a system by, say, selecting three symbols in a certain order from a set of nine symbols. Rather than requiring confirmation of each symbol after entry, it may be preferable to allow further attempts if the user makes a mistake. For students who find selecting three symbols difficult then a simpler login, selecting just one or two symbols should be available. For more advanced learners, login sequences could have a learning aspect to them, for example, it might symbolize what a person needs to remember before leaving the house, such as keys, wallet, and mobile phone. Another solution that could be explored in the future is the use of biometrics, such as fingerprint recognition, allowing students to access the system in a simple way. However the benefit of learning a more standard method of login is that it gives students practice when using computer systems in general.

Clear Menu to Select and Launch Programs

Learning resources within the VLE should be presented in a clear, attractive, and accessible way so that students can decide which program to choose without help from a tutor. A menu of program names simply presented as text will be too complex for many of the students with

cognitive disabilities. Instead menu items should appear as bright, simple, and distinct images. The inclusion of the name of the program with the image will assist those students who cannot read or identify words. The use of speech output to read out the names as the user moves the mouse cursor over them or when the switch scan rectangle frames them will also make the menu more accessible.

Tutor Information and Control

Indication of Appropriate Educational Level

Students are assessed as being at a certain level for literacy and numeracy (e.g., Entry level for literacy, Level 1 for numeracy). It is helpful if learning programs are labeled with the appropriate level as a guide for tutors. The VLE could also include a customization feature to present to each student programs appropriate to his/her particular level.

Easy Set Up for Individual Students

If the computer is shared by several learners, the tutor should be able to easily modify the input device settings and user interface to suit different students' needs. The VLE should be able to manage this by changing the settings as each user logs in. In the Portland Partnership project, a new switch was designed to hold the settings for each student (e.g., preferred switch scan rate and symbol set) and to communicate them to the VLE via Bluetooth technology (Brown et al., in press).

Learning Program Content

Student Identification with Learning Materials

In general, students like to see or use content that they can identify with, for example, life skills such as washing, dressing, or making breakfast. Showing mishaps like burning toast can be reassuring for students provided they are advanced enough to see this as representation of an event. However others at an earlier development stage may find such events disconcerting.

Most students enjoy making presentations from pictures or video sequences that include themselves, their tutors, or their fellow students. Many of the Portland Partnership programs were specifically designed to include people in wheelchairs performing actions (dancing at a party, playing in a band, or playing football) to which wheelchair students could relate.

Fun Elements

Programs containing fun elements and details are normally enjoyed by students and encourage them to use the program again. For example, in a program showing a pop band, the name of one of the colleges was printed on the drum. Visual humor in programs such as Party and Cinema also appealed to the students. Another example is the Web site program Singing Horses, produced by Sveriges Television (SVT, 2002), a national publicly-funded television broadcaster in Sweden. Within it, four horses are shown standing by a fence. Clicking on each

horse animates it to sing a part in harmony, providing an enjoyable cause and effect activity allowing fairly complex musical sounds to be made with simple inputs.

Variation to Maintain Interest

Students enjoy interactive scene programs, but if the programs follow a set sequence, they can soon become too familiar. Minor levels of variation can create interest for the students, such as in the display of colors in a fireworks program when the user clicks on a moving rocket. In a music program with a pop band, the musicians can play one of several different bursts of music, selected randomly, to add variety.

Versions to Match Different Ability Levels

It may be appropriate to develop different versions of a program to match the various cognitive and physical ability levels of the learners. The Portland Partnership program Pairs had different versions, one using colors and the other using time, to provide different levels of learning targets for students at various stages of learning. This approach also provides a learning path for students to follow.

Allow Students to Function on Par with Mainstream Users

An attraction of e-mail is that it allows students to communicate in the same way as mainstream users. This may be used for students to communicate with the tutor and to receive instructions or help. Sharing images attached to e-mail messages is also an attractive facility for severely disabled students.

Games Allowing Interaction or Competition with Classmates

Students with sufficiently advanced development enjoy games where they can interact or compete with each other. However players will often have very different abilities and reaction times. If the program can detect if one player is always winning and then adapt to make it easier for the other player, then this may be an effective strategy. Tutors also value programs that can be played by two or more students together where they can learn turn-taking skills, such as throwing and catching a ball across a net. A program like Singing Horses, mentioned previously, could also be extended to be a group activity, with each of four students controlling one of the horses.

Interaction Facilities

Speech Output Support

Students with cognitive disabilities can be assisted with speech output of program prompts, selection menus (possibly synchronized with switch scanning), and e-mail messages. Therefore, the inclusion of recorded or synthetic speech output support should be considered where possible. It has been noted that a human voice may be more intelligible and appealing for learners at earlier milestones (Copestake & Flickinger, 1998) although synthetic speech is

acceptable if it has a natural sound (Tiresias, 2006). In the Portland Partnership learning programs, the general approach was to read aloud an instruction with a pre-recorded voice to guide the user when the program started. It is important that the speech output always matches the current stage of the learning program or game. Within the classroom, speakers and headphones should be provided to make best use of speech and audio facilities within the programs.

Exploration of On-Screen Elements

Within interactive scene programs, students will expect to be able to interact freely with all the items shown. For example, in a kitchen where they could select the food mixer or kettle, they might also expect to be able to open drawers and cupboards. Providing interaction or animation for as many objects as possible in a scene seems to increase the student's engagement with it.

Design to Match the Range of Student Capabilities Within the Classroom

Within the VLE a range of programs should be developed to match the range of student capabilities within the classroom. In general, though, learning programs should be simple to operate without requiring complex interactions or manipulations. For example, in a game that requires the matching of paired cards, the student may be shown a card and simply have to click another that matches it. There may be a requirement for even simpler programs for certain groups of students, where they simply click their switch to step through a sequence of images that illustrate a story that is read aloud (using recorded or computer-generated speech) or to hear a sequence of interesting sounds. More advanced students may be able to manage and benefit from more challenging interactions, such as dragging objects across the screen or clicking on a moving object. Some programs may be designed to offer different levels of use to match students' abilities, allowing them to do more as they progress.

Clear and Consistent Switch Scanning Rectangle

For switch users, the scan rectangle should stand out clearly from the background. Ideally all programs within a VLE should have the same style of scan rectangle, but allowing the appearance to be customized for individual users. For mouse users it should be possible to turn the scan rectangle off.

Clear Areas to Click and Consistent Navigation

When a student first uses a program, he/she may click on different items to find out how to activate them. For example, in a football game he/she may click on the players, the football, or the goal. Clickable objects should therefore be very intuitive and be made large enough for students with more limited motor abilities. If the user needs to click on a particular point within a program (e.g., the fuse of a firework), this could be indicated with an arrow. The technique of *audio rollovers* may also be used. When the cursor moves over a clickable area, its name or an instruction is spoken, for example, "Kettle" or "Click here to turn on the kettle."

Navigation buttons within the VLE and learning programs should be presented in a consistent style. In addition, they should be placed in consistent locations to help the student learn to operate them more easily.

Feedback to Students

Alternatives to Words and Numbers

Many severely disabled students cannot read text and so instructions or captions (e.g., *the score*) are not always accessible to them. An alternative for some games is for the score to be shown as a number in a large text size or as a line of symbols, such as footballs, to represent the number of goals. In the card game Snap, large ticks and crosses were displayed to indicate a match or no match.

Indication of Success or Failure

Most students need some kind of feedback or reward to motivate them to complete a program and to progress to higher educational levels. A combination of visual and audio feedback (e.g., a smiling clown's face with a fanfare for a correct answer and a frowning clown with a downbeat sound for an incorrect one) is an effective way to provide this. However it should be possible to control the volume of any sounds or to turn them off if they are disturbing others in the classroom.

Certificates of Completion or Achievement

Learning programs can be designed to generate a personal certificate that can be printed to show what the student has achieved. This can boost the confidence of each learner and give him/her an added sense of satisfaction. The VLE itself may be designed to generate the certificates containing the student's name, the program he/she used, the date awarded, and possibly the score attained. The program could also generate a smiley scale for the learner to provide feedback on what the student thought about the activity; such a process was used successfully in the WWAAC project (Nicolle et al., 2004).

CONCLUSIONS

The evaluation has shown that the Portland Partnership software has had a positive impact on learning by students with severe cognitive and physical disabilities. This is supported by the comments from the tutors who experienced positive progress for most of the students involved in the trials. The VLE was tested only to a limited extent, but the feedback from the tutors and students indicated that it is a useful environment for students to access learning programs and for tutors to manage this process. Elements such as the login facility worked well and students particularly enjoyed the idea that they could send messages to others, although in a simpler form than standard e-mail. A timetabling facility also gave students the chance to choose activities for themselves.

The successful development of the learning programs has been based upon successful project collaboration between developers and educationalists, and through a process of iterative design and development that responded to evaluation feedback and tutor comments. To meet the needs of students with less developed capabilities, the Portland Partnership project has started to develop some very simple programs controlled by just a switch to step through a sequence of screens without having to control a mouse or scan rectangle. These include Color Burst, Make a Pizza, and What's Next? (a sequencing program). The further development of such learning programs and VLE facilities should maximize the number of students with severe physical and cognitive impairments who can benefit from them.

ENDNOTE

1. In the UK, Colleges of Further Education (FE) provide courses for students at age 16 and above, from basic skills upwards, particularly work-related training for commerce or industry. These include apprenticeships, National Vocational Qualifications (NVQs), General National Vocational Qualifications (GNVQs), City and Guilds, National Certificates and Diplomas, General Certificates of Secondary Education (GCSE), AS and A Levels. At Colleges of Higher Education (HE) students aged 18 and above study for higher level qualifications including Higher National Certificates (HNC) and Higher National Diplomas (HND), foundation degrees, degrees or postgraduate qualifications.

REFERENCES

- Barnes, D., & Walter, R. (2000). *Internet for all*. London: David Fulton.
- Brown, D. J., Battersby, S. J., Standen, P. J., & Anderton, N. (in press). Design, development, evaluation and manufacturing of a wireless based switch for use by people with severe physical and cognitive disabilities. *The ACM (Association for Computing Machinery) Transactions on Computer-Human Interaction (TOCHI) [Special Issue: Web Accessibility]*.
- Burkhart, L. J. (2002). Multi-modality support for children on the autism spectrum. In *2002 ISAAC Biennial Conference Proceedings: CD-Rom* (pp. 162–163). Odense, Denmark: ISAAC [International Society for Augmentative and Alternative Communication].
- Colven, D., & Lysley, A. (2001). Standards in mainstream and adaptive interface design required for efficient switch user access. In C. Stephanidis (Ed.), *Universal access in HCI: Towards an information society for all* (Vol. 3; pp. 900–904). Mahwah, NJ: Lawrence Erlbaum Associates.
- Copstake, A., & Flickinger, D. (1998, May). Enriched language models for flexible generation in AAC systems. Paper presented at the California State University, Northridge, Center on Disabilities' Annual International Technology and Persons with Disabilities Conference, Los Angeles, CA, USA. Retrieved March 18, 2006, from http://www.csun.edu/cod/conf/1998/proceedings/csun98_122.htm
- Department for Education and Skills, and the Learning and Skills Development Agency [DfES & LSDA]. (2002). *Adult Pre-entry curriculum framework for literacy and numeracy* (ISBN 1 85338 739 8). (Available from The Basic Skills Agency, Admail 524, London, WC1A 1BR, UK).
- Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2003). *Human Computer Interaction*. Upper Saddle River, NJ: Prentice Hall.
- Dunn, S. (2003). *Return to SENDA [Special Educational Needs and Disability Act]?: Implementing accessibility for disabled students in virtual learning environments in UK Further and Higher Education*. London: City University. Retrieved January 27, 2006, from <http://www.saradunn.net/VLEproject/>

- Gill, J. (2004). *Access-Ability: Making technology more useable by people with disabilities*. Retrieved January 27, 2006, from <http://www.tiresias.org/guidelines/access-ability/> (Also available from the Royal National Institute of the Blind, 105 Judd Street, London WC1H 9NE, UK.)
- Gill, J. (2006). *Design of accessible information and communication technology systems*. Retrieved January 27, 2006, from <http://www.tiresias.org/guidelines/index.htm>
- Heim, J., Endestad, J., Skjetne, J. H., Maguire, M., & Vereker, N. (1998, January). *Requirements specification and evaluation for user groups with special needs: Project report: Requirements Engineering and Specification in Telematics (RESPECT; EC Telematics Applications Project TE 2010; Deliverable D6.2, Version 1)*. Available from the Ergonomics and Safety Research Institute, Loughborough University, Holywell Building, Holywell Way, Loughborough, Leicestershire, LE11 3UZ, UK.
- Itoh, H. (2002). Developing an effective communication system using graphic symbols at a preschool for young children with autism. In *2002 ISAAC Biennial Conference Proceedings: CD-Rom* (pp. 378–379). Odense, Denmark: ISAAC [International Society for Augmentative and Alternative Communication].
- Martinez, M. (2002, May 7). What is personalized learning? *The e-Learning Developers' Journal: Strategies and Techniques for Designers, Developers, and Managers of eLearning*. Retrieved March 17, 2006, from <http://www.elearningguild.com/pdf/2/050702dss-h.pdf>
- Mayer-Johnson (n.d.). *Pictorial Communication System (PCS)*. Retrieved 15 March, 2006, from <http://www.mayer-johnson.com/AboutUs.aspx>
- Murphy, J. (1998, Autumn). Talking mats: Speech and language research in practice. *Speech & Language Therapy in Practice*, 11–14. Retrieved January 27, 2006, from <http://www.speechmag.com/archives/joanmurphy2.html>
- Nicolle C., Poulson, D., Black, K., Clarke, M., Lysley, A., & Magnuson, T. (2004). Final user interface report: The evaluation plan, *WWAAC Deliverable 13*. Retrieved January 27, 2006, from www.wwaac.org
- Nielsen, J. (1994). *Usability engineering*. San Francisco: Morgan Kaufmann.
- Portland Partnership. (2005). Retrieved January 27, 2006, from <http://www.portlandpartnership.net>
- Poulson, D., & Nicolle, C. (2004). Making the Internet accessible by people with cognitive and communication impairments. In *UAIS (International Journal Universal Access in the Information Society): Special Issue on Guidelines, Standards, Methods and Processes for Software Accessibility*, 3(1), 48–56.
- Rogers, Y., Sharp, H., & Preece, J. (2002). *Interaction design: Beyond human-computer interaction*. Chichester, UK: John Wiley & Sons.
- Schlosser, R. W., Belfiore, P. J., Nigam, R., Blischak, D., & Hetzroni, O. (1995). The effects of speech output technology in the learning of graphic symbols. *Journal of Applied Behavior Analysis*, 28, 537–549.
- Section 508 of the U.S. Rehabilitation Act. (n.d.). *Electronic and Information Technology of the Rehabilitation Act (29 U.S.C. 794d), as amended by the Workforce Investment Act of 1998 (P.L. 105-220), August 7*. Retrieved January 27, 2006, from <http://www.section508.gov/index.cfm?FuseAction=Content&ID=14> (Also available from U.S. the General Services Administration, Office of Government-wide Policy, 1800 F Street NW, Room 1234, Washington, D.C. 20405 USA.)
- Special Educational Needs and Disability Act [SENDA]. (2001). Retrieved January 27, 2006, from <http://www.opsi.gov.uk/acts/acts2001/20010010.htm>
- Stiles, M. J. (2005). Disability access to virtual learning environments. Retrieved March 17, 2006, from http://www.techdis.ac.uk/index.php?p=3_8_20051410041022
- Sturm, J. (2002). Literacy instructional practices of general education: Implications for AAC users. In *2002 ISAAC Biennial Conference Proceedings: CD-Rom* (pp. 216–217). Odense, Denmark: ISAAC [International Society for Augmentative and Alternative Communication].
- Sveriges Television [SVT]. (2002). *Singing horses program*. Retrieved January 27, 2006, from <http://svt.se/hogafflahage/>
- Techdis. (n.d.a). *Approaches to content creation*. Retrieved March 17, 2006, from http://www.techdis.ac.uk/index.php?p=1_20040511081154

- Techdis. (n.d.b). *Making e-learning materials usable, customisable and therefore more accessible?* Retrieved March 17, 2006, from http://www.techdis.ac.uk/index.php?p=3_7_20051211011132
- Tiresias. (2006). Guidelines for audio output. Retrieved March 18, 2006, from <http://www.tiresias.org/guidelines/audiooutput.htm>
- Widget Software. (n.d.). *Widgit Rebus Symbols*. Retrieved 16 March, 2006, from http://www.widgit.com/symbols/about_symbols/intro_2_symbols/index.htm
- World Wide Web Consortium Web Accessibility Initiative [W3C–WAI]. (2006a). *Web Content Accessibility Guidelines Working Group*. Retrieved January 27, 2006, from www.w3.org/WAI/GL/
- World Wide Web Consortium Web Accessibility Initiative [W3C–WAI]. (2006b). *Web Content Accessibility Guidelines*. Retrieved January 27, 2006, from <http://www.w3.org/WAI/intro/wcag.php>
- World Wide Web Consortium Web Accessibility Initiative [W3C–WAI]. (2005). *Introduction to Web Accessibility*. Retrieved January 27, 2006, from <http://www.w3.org/WAI/intro/accessibility.php>
- World Wide Augmentative and Alternative Communication [WWAAC]. (n.d.). Project consortium Web site. Retrieved January 27, 2006, from <http://www.wwaac.org>
-

Authors' Note

The authors would like to acknowledge the help of their colleagues within the ESF Portland Partnership and, in particular, the project coordinators, Matthew Harrison and Rob Nicholls (Portland College). They are also grateful to the college tutors Helen Evans, Kathryn French, Dian Fennell, and Govan Mears, for supporting the user evaluation sessions, and to the students for their enthusiastic participation.

All correspondence should be addressed to:
Martin Maguire
Ergonomics and Safety Research Institute
Loughborough University
Holywell Building, Holywell Way
Loughborough, Leics, LE11 3UZ, UK
m.c.maguire@lboro.ac.uk

Human Technology: An Interdisciplinary Journal on Humans in ICT Environments
ISSN 1795-6889
www.humantechnology.jyu.fi

Level	Curriculum elements
<p>Milestones 6</p>	<p><i>LITERACY</i></p> <ul style="list-style-type: none"> • Listen and respond to familiar people. • Demonstrate that they are paying attention. • Follow requests and instructions, and use phrases containing up to three key words, signs, or symbols. • Use facial expression to enhance meaning. • Ask simple questions to obtain information. • Respond to familiar people in one-on-one discussion. • Take turns. • Cooperate in a group. <p><i>NUMERACY</i></p> <ul style="list-style-type: none"> • Join in rote counting to 5. • Understand one-to-one correspondence in a range of contexts. • Count reliably up to three objects, and up to five with inconsistencies. • Recognize the numerals 1, 2, and 3, and with inconsistencies 4 and 5.
<p>Milestones 7</p>	<p><i>LITERACY</i></p> <ul style="list-style-type: none"> • Listen and attend to familiar people. • Listen to simple questions on familiar topics and give answers. • Listen to and follow simple instructions and requests of three to five words. • Communicate ideas, choices, and events and make reference to the past, present, future. • Use the conjunctions <i>and</i> and <i>but</i> to link ideas and add new detail which is beyond that directly prompted or requested. • Make simple requests. • Ask simple questions of others. • Make simple statements about simple and personal matters. • Contribute appropriately to simple oral interactions, including conversations and discussions. <p><i>NUMERACY</i></p> <ul style="list-style-type: none"> • Join in rote counting to 10. • Count up to five. • Use the numerals 1 to 5 (e.g., using a large face calculator or keyboard). • Relate numbers to collections of objects reliably to three, and with support to five. • Add and subtract single digit numbers reliably to three and with support to five. • Use the ordinal numbers <i>first</i> and <i>second</i> (e.g., people in a queue). • Recognize mathematical symbols (=, +, . and -) and know how they are applied.

Level	Curriculum elements
<p>Milestones 8</p>	<p><i>LITERACY</i></p> <ul style="list-style-type: none"> • Use key words, signs, and symbols in communicating about own experiences and recounting a narrative. • Ask questions using key words, signs, and symbols to obtain information. • Use growing vocabulary to convey meaning beyond words of purely personal experience. • Contribute proactively to simple oral interactions, including conversations and discussions. <p><i>NUMERACY</i></p> <ul style="list-style-type: none"> • Join in rote counting to 10. • Continue rote counting upward from a given small number. • Be able to compare two groups of objects with up to five items in each, communicating which is more or less. • Work with the numerals from 0 to 10, know their values, recognize them, use them and (with some inconsistencies) record them. • Relate and add numbers of collections of objects reliably to five, and with support to 10. • Subtract single digit numbers reliably from numbers 0 to 5, and with support from numbers to 10. • Use ordinal numbers <i>first</i> to <i>fifth</i>. • Recognize mathematical symbols (=, +, and -), such as when working with a calculator to input numerals from 0 to 10.
<p>Entry Level 1 Literacy</p>	<p><i>READING COMPREHENSION</i></p> <ul style="list-style-type: none"> • Follow a short narrative on a familiar topic or experience. • Recognize the different purposes of texts at this level. <p><i>GRAMMMAR AND PUNCTUATION</i></p> <ul style="list-style-type: none"> • Read and recognize simple sentence structure. <p><i>VOCABULARY, WORD RECOGNITION, AND PHONICS</i></p> <ul style="list-style-type: none"> • Possess a limited, meaningful sight vocabulary of words, signs, and symbols. • Decode simple regular words. • Recognize the letters of the alphabet in both upper and lower cases. <p><i>WRITING COMPOSITION</i></p> <ul style="list-style-type: none"> • Use written words and phrases to record or present information. <p><i>GRAMMAR AND PUNCTUATION</i></p> <ul style="list-style-type: none"> • Construct a simple sentence. • Punctuate a simple sentence with a capital letter and a full stop. • Use a capital letter for personal pronoun "I." <p><i>SPELLING AND HANDWRITING</i></p> <ul style="list-style-type: none"> • Spell correctly some personal key words and familiar words. • Write the letters of the alphabet using upper and lower cases. • Use basic sound-symbol association to help spelling, as appropriate for the needs of the learner.

Level	Curriculum elements
Entry Level 1 Numeracy	<p><i>WHOLE NUMBER</i></p> <ul style="list-style-type: none"> • Count reliably up to 10 items. Read and write numbers up to 10, including zero. • Order and compare numbers up to 10, including zero. • Add single-digit numbers with totals to 10. • Subtract single-digit numbers from numbers up to 10. Interpret +, -, and = signs in practical situations for solving problems. • Use a calculator to check calculations using whole numbers. <p><i>COMMON MEASURES</i></p> <ul style="list-style-type: none"> • Recognize and select coins and paper currency. • Relate familiar events to times of the day, days of the week, and seasons of the year. • Describe size and use direct comparisons for the size of at least two items. • Describe length, width, height, weight, capacity and use direct comparisons for length, width, height, weight and capacity of items. <p><i>SHAPE AND SPACE</i></p> <ul style="list-style-type: none"> • Recognize and name common 2-D and 3-D shapes. • Understand everyday positional vocabulary (e.g., between, inside, or near to). <p><i>DATA AND STATISTICAL MEASURES</i></p> <ul style="list-style-type: none"> • Extract simple information from lists. Sort and classify objects using a single criterion. • Construct simple representations or diagrams, using knowledge of numbers, measures or shape and space.
Entry Levels 2 & 3	The content of these levels are an extension of the above.

The complete documents for Pre-entry Adult curriculum in the UK are published jointly by the Department for Education and Skills and the Learning and Skills Development Agency (DfES & LSDA, 2002).