AN EMERGENT METHODOLOGY FOR THE DESIGN, DEVELOPMENT AND IMPLEMENTATION OF VIRTUAL LEARNING ENVIRONMENTS.

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ABSTRACT

As any research field graduates from infancy to youth (or it may be argued survives in this case) there is a need to structure and order the methods you have used for getting answers to questions. This should allow us rationalise these methods and select the ones that have given good and practical answers. Successful methods can then be embedded within an overall methodology for the design, development and implementation of the Learning In Virtual Environments (LIVE) program. This program consists of virtual environments (VE) to teach basic life, communicational and personal and social skills, developed in conjunction with the staff and pupils at the Shepherd School.

This overall methodology will be presented in a series of five stages that exert a contingent influence on the final nature of any virtual learning environment. Stage one seeks to embed any development in this field in contemporary educational theory. Stage two looks at the role of parents, teachers, pupils and caregivers in the development of these VE. Stage three considers the role of testing in refining any developments we make, whilst stage four considers the ethical implementation of these learning aids in the classroom. Finally, stage five looks at the development of guidelines for the optimal design of virtual learning environments for the various types of learning.

Keywords: virtual environments, methodology, life skills, communication.

INTRODUCTION

The LIVE project was established five years ago, in partnership with the Shepherd school, to investigate whether VE had a role to play in special education. Where as the Shepherd school used drama, three dimensional art, solar-visualisation rooms and experiential techniques to stimulate and educate their students, virtual reality systems offered a platform for independent movement and autonomous action in a rich and varied set of electronically generated environments, all accessible in a classroom.

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The teaching curriculum at the Shepherd school is based around the development of very practical life skills that will afford students some degree of independent living later on in life. Indeed one of the first applications suggested was the production of VE to teach the meaning of Makaton Symbols. These are a series of two dimensional icons, and used in conjunction with British Sign Language act as a communicational system by students with severe learning and language disabilities.

Why a VR system approach in this case? Several reasons were put forward. First, some students are so disabled that the may only ever learn the meaning of ten symbols in their entire school life. Even if it were proven that the VE method didn't encourage the students to learn the meaning of more symbols or at a faster rate, they still provided a stimulating and alternative teaching method, especially important for both teachers and pupils in the light of the former sentence. Second, a classroom setting can be extremely limited in both sufficient objects to represent the meaning of each Makaton symbol, and then with a sufficient range of each object to ensure that students do not over specify what each symbol can represent. Using VE, a whole world of experience can be brought into the classroom, with a range of examples for each symbol, a range of settings and modes of interactions that may not be possible otherwise. Other traditional teaching methods were also deemed flawed, for example a picture card may be used to teach the meaning of the symbol for car, and the use of a two dimensional abstract representation to teach the meaning of another two dimensional abstract icon was questioned.

As we have found subsequently there is usually more than one reason to develop a virtual learning environment. It is hardly ever the only solution however, and should be used in conjunction with other methods, adding to a battery of educative tools to stimulate students with severe learning difficulties. And virtual experience should never be used as an excuse for not providing real world experience, but more rather to fill in experience gaps, when it is not possible for students to gain regular first hand experience due to physical disability, logistical constraints and well meaning but over protecting parents and teachers.

Since this first application was developed we have developed a range of VE to teach basic life experiences (City, House, Supermarket, Skiing), interactive sound environments for students within the Autistic Continuum, reaction worlds for profound and multiply disabled children who can only operate switches and finally environments to teach health education to students with moderate learning difficulties.

It has always be our aim to test and evaluate the learning environments we have produced, but initially this testing phase was very much on an ad-hoc basis, including an initial evaluation of the usability of the available input devices and a study to determine whether students could recognise and articulate the meaning of objects they could do so in the real world. This then gave way to a much more systematic approach, borne out of a developing partnership with the Department of Learning Disabilities, based within the Queens Medical Centre also at the University of Nottingham. Since then we have sought to determine the transferability of skills learnt in a VE to the real world, whether the use of VE can encourage self directed activity and the testing and design of appropriate navigation and input devices for students with a huge range of physical and cognitive abilities.

But it is the five factors that drive the creation of any new virtual learning environment (and

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indeed it may be argued the program itself), that have emerged into a methodology to describe a potential role of VE in special education that will be the main subject of this paper.

STAGE1: Embedding the conceptualisation and design of virtual learning environments in contemporary education theory.

New technologies are often introduced first into mainstream education, only later to be adapted for special education use. In this instance however, the role of VE in special education appears at least as pertinent in a special needs setting as it does elsewhere. There exists a strong mapping between the attributes of VE and the goals of what is considered good contemporary special educational practices.

First, their use may encourage **self directed activity.** Many students with learning difficulties experience so little control over things other children take for granted that they may assume they are going to play a passive role all the time (Simms, 1994). VE can stimulate a child's curiosity and to this end environments have been built that allow a student to enter an underground station and take a tube train to the destination of their choice or to find out what happens when an empty kettle is boiled. Bruner (1968), Vygotsky (1978) and Piaget (see wood 1988) have emphasised the importance of self directed activity in their theories. For students who have limited opportunity to do so in real life, VE can offer a rich and varied set of opportunities to initiate self directed activity in a safe arena.

Second, given that their use might promote self directed activity in a group of students who are said to be deficient in this area, we must by good design build VE that are **motivational** and inspiring to use. Stuart and Thomas (1993) believe that whereas the age of television has bred passive disengaged students with short attention spans, the use of VE may be able to captivate students and foster their active involvement in their own education. Our 'develop-test-refine' methodology will employ empirical research to establish the optimal design of VE for the various types of learning, one of the criterion of which being whether students are motivated to use them.

Third, the **role of play** is given high importance in developmental theories of education. Students with disabilities may often be protected for longer than others (Shakespeare, 1995), often not gaining experiences necessary for further development. Vygotsky (1978) emphasised the importance of play in liberating children from constraints, whilst Bruner (1968) describes how play allows the systematic uncoupling of means and ends. Students can embody themselves in other characters and play 'lets pretend'. Brenda Laurel (1991) points toward the strong identification that players can feel with artificial characters in a computer database as an example of the human capacity for *mimesis*, to which Aristotle attributed the soul changing power of drama. Our team has adapted the virtual city to teach road safety; credit points are given for good action, for instance using a pedestrian crossing whilst credits are lost for crossing the road at an unmarked junction. The aim is to gain credits to stay alive in the game.

Fourth, many computer learning systems rely on abstracted symbol systems such as English or Mathematics. VE have their own **natural semantics** (Bricken, 1991); the qualities of objects can

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be discovered by direct interaction with them. Children with learning difficulties are commonly termed 'concrete thinkers', learning best through direct through practical experience. Our virtual house looks and operates very much like a real house, with a kitchen in which you can learn to make a simple snack. This form of learning, independent of abstracted symbol systems, is ideally suited to the abilities of students with severe learning disabilities.

fifth, desktop VR platforms offer a **shared public experience**. Both student and facilitator can share and discuss the environment. Bruner (1968) has drawn attention to the social context out of which skills develop. The importance of the role of instruction has been developed by Vygotsky (1978), in his concept of the 'zone of proximal development' defined as the distance between a child's actual developmental level as determined by independent problem solving and the higher level of 'potential development as determined through problem solving under adult guidance or in collaboration with more capable peers'. This is particularly pertinent to our environments used to encourage language development, where the student is encouraged to respond to a virtual manakin and articulate the meaning of symbols encountered to a teacher, carer or more capable peer.

Sixth, VE can act as a **great equaliser of physical abilities.** Provided the student can operate simple input and navigation devices (joysticks, switches, touchscreens), they can move through and interact with environments they may be restricted from doing so in real life, and gain experience and learn skills that their physical disabilities may prevent them from doing so in real life. This of course depends on good interface design an issue already extensively investigated by our team (Hall, 1993 and Crozier, 1996). People with disabilities already face a huge range of barriers to social and educational interaction in real life and we do not want to compound these by poor interface design and create a new set of barriers to interaction with VE (Vanderheiden *et al*, 1992).

And **seventh**, VE can provide a **safe space** in which to practice skills that are dangerous and risky to do so in real life. Problems can be encountered and consequences demonstrated without exposing the student to any real danger. A pilot project is now underway in Nottingham to develop virtual learning scenarios to teach health education to students with moderate learning difficulties. In this way a student might be approached by a stranger in the virtual city, and we can teach appropriate behaviour in response to such a situation in an non-abstract and safe environment.

STAGE 2: The role of teachers, parents, caregivers and students in the development of virtual learning environments.

It is a central policy of VIRART that all virtual learning environments should follow a Develop-Test-Refine process. It is the pupils, teachers, parents and caregivers who should play a major role in the developmental stage of any virtual learning project. They suggest the original application, define what it should look like, its functionality, multimedia facilities and modes of access.

By tapping into this knowledge resource we can ensure that any application developed will be relevant and useable by the group of students to which it is aimed. This is especially important in the field of disability where resources are already stretched and any new innovation should bring

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maximum benefit, especially when one considers that to provide such a resource in a special education classroom may drain resources from other projects.

The role of teachers and parents in this developmental stage also extends to the platforms on which the virtual learning experience will be displayed. When we first approached the Shepherd School their only reservation about the project was centred around media speculation of the hypothesised health and safety risks associated with the use of head mounted displays. For this reason all of our developments take place on desktop equipment. These platforms also have the advantage of being affordable by special schools, an important issue to consider in the developmental stage of any virtual learning project. It would be unwise to place any student with a learning disability in a headmounted display until the hypothesised physiological, psychological and visual side effects have been rigorously established. The study VIRART has been commissioned to undertake by the Health and Safety Executive (HSE) has so far established:

* Some participants, in some VR systems, with some VE, do report various side effects.

* The most common reported side effects are dizziness, nausea, 'disorientation', and a group of symptoms that might be categorised as visual fatigue.

* For most participants, any side effects wear off quite quickly after VR participation finishes.

Even when the results are extensive and conclusive the teachers at the Shepherd School have pointed out that these issues are likely to be much more complex for students with learning difficulties.

Teachers, parents and caregivers will also have a role to play in the formulation and writing of any manuals or tutoring systems describing how to set up and use the LIVE system to maximum effect. Again this is important if the virtual learning environments are to be used in the home as well as the classroom or rehabilitation centre.

STAGE 3: The role of testing in the refinement of virtual learning environments.

Along side developmental issues, testing plays a major role in shaping and defining virtual learning environments. A brief description will now follow of the major tests we have carried out in the LIVE program and the subsequent effects they have had.

Test1: Can students recognise and articulate the meaning of Makaton symbols they knew in real life?
This initial test was carried out using a virtual warehouse containing a number of different objects, a series of randomly flashed Makaton symbols, representing the meaning of each of these objects and eight randomly selected students, some of which had previous computer experience. In summary, our findings were:

* Two of the students experienced no trouble in examining each symbol in turn and then quickly

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and accurately identifying the object that each randomly generated Makaton symbol represented.

* Three of the students appeared to recognise objects and handsigns but failed to match the correct object with the randomly flashed Makaton symbol.

* The other three students correctly matched some objects with the correct Makaton symbol.

From this initial test the team was encouraged to continue with its program to teach Makaton symbols, but to place the objects in future in their correct contextual setting and use other clues (such as scanned images and sound) to help students to accurately identify virtual objects. The Derbyshire Assessment Program was also adopted as a method of monitoring the ability to students to recognise and articulate the meaning of grouped sets of words.

Test2: Can the use of virtual learning environments encourage self directed activity in students with learning difficulties?
Self directed activity as we have discussed is one of the areas students with learning difficulties are said to be deficient in. The team decided to investigate whether students were using the virtual learning environments in this way or in a more conventionally didactic manner.

For this test we used the Makaton environments and recorded the students autonomous moves, such as pointing and the use of the joystick and mouse against instructions issued by the teacher. What was found was that where as in the first instance the teacher was mainly directing the students as to what to do and where to go next, these directives began to fall away sharply and be replaced by the students own autonomous moves.

This finding led us to believe that as with any learning system there will be an initial learning curve, but that the use of this system can encourage self directed activity in students with severe learning difficulties, allowing them to direct their own course of events, something that they might not expect to do so much in the real life.

Test3: Can students generalise basic skills they have learnt in virtual environments to the real world?
This study investigated whether basic shopping skills learnt in the virtual supermarket could be transferred to the real world. A control and experimental group, both containing around ten students of similar real world shopping experience, was used. A baseline assessment tested their ability at a local supermarket to select items using a picture based shopping list. There was no significant difference in the two groups at this stage, both in the number of correct items picked up first time and the total time elapsed for the shopping experience.

There then followed a period of virtual training. The experimental group each experienced between three and ten sessions using the virtual supermarket to select a series of goods from the virtual aisles using a picture based shopping list. The control group were also allowed to use a series of virtual learning environments, however they were not allowed to use the virtual supermarket.

All of the students then revisited the real supermarket. Again challenged to select a variety of goods, analysis of the subsequent data revealed that not only did the experimental group have a

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significantly faster overall shopping time but they were also more accurate, selecting the correct item off the shelf first time on a more frequent basis than the control group.

This is a very encouraging result, proving that it is possible to use VE to teach basic life skills to students with severe learning disabilities. It is not planned that the virtual supermarket be used as a replacement for real world experience, but more rather as a support, used on a frequent or every day basis to build skill in between the times when students can visit a real supermarket in school time or supported by their parents.

Test4: Appropriate input devices for students with motor skills disabilities.
People with disabilities already experience a whole range of access issues in their lives and we do not want to create an extra set of barriers when creating virtual learning environments. For this reason we needed to review the currently available navigation devices (spaceball, spacemouse, joystick, keyboard) and input devices (mouse, touchscreen, keyboard, switch) and assess their usability within VE by students with a wide range of motor skills abilities.

Our first analysis (Hall, 1993), a population stereotype study, looked at the usability of the currently available navigation devices and revealed that a joystick which allowed just two simultaneous degrees of freedom created least frustration in students when attempting to navigate from one virtual position to another.

The latest study (Crozier, 1996) investigated the usability of input devices and makes recommendations for the operational improvement of touchscreens within VE and software to support the use of more specialist devices, such as switches and soundbeam, to allow access to VE by students with the most severe motor skills disabilities.

Test 5: Can students with severe learning disabilities transfer spatial skills they have learnt in a virtual environment to the real world?
This current and on going experiment has used a virtual model of the Shepherd School. There are tremendous training and rehabilitation implications if it is possible to use VE to teach spatial and navigational skills to this group of students. What is planned is a virtual treasure hunt game where students receive clues as to where the treasure is buried in the virtual school. The students will then be challenged to find the treasure in real life, thus indicating whether routes can be learnt in a VE and related to an existing building.

STAGE 4: The implementation of the virtual learning environments in a classroom setting.

The ethics involved in the placement of virtual learning environments are important drives in the way we shape and form them. Issues of how they are placed in the curriculum, whether they drain resources from other important projects, whether they unnecessarily raise expectations or simply are used as a convenient excuse for real world experience should all be considered at the out set of any project. There are many ethical issues which programmers must consider when designing educational VE for students with severe learning disabilities. Three central issues are:

* the need to include appropriate content.

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* the need to provide context and setting.
* their own power in constructing users' virtual experiences.

Each of these three issues will now be discussed in more detail.

Debates about the appropriate content of VE gain additional force when they are intended for educational use by students with severe learning disabilities, who are typically considered more vulnerable and open to suggestion than others. Desktop VE have an obvious resemblance to television, but because they promote active engagement rather than passive viewing (Stuart & Thomas, 1991) their potential influence is greater. One study by Calvert & Tan (1994) looked at the impact upon levels of arousal and aggressive thoughts in 36 non-learning disabled young adults of either watching or playing a violent desktop VE game, and found that those playing the game showed higher levels of arousal and more aggressive thoughts than those just watching. The content of educational VE must be carefully chosen to make sure not only that they are appropriate to the task, but also to ensure that no "hidden agendas" are inadvertently introduced.

Important though they are, debates about content are not unique to VE and do not go to the root of most people's concern about their educational use. What is more specific to VE is their potential to provide experiences devoid of their usual social context. Actions in VE do not have the real social costs associated with their real world analogues and Whalley (1993) argues that as a result continual use of VE might foster infantile thinking and feelings of omnipotence, especially in those whose ability to negotiate their place within the socially shared physical world is already impaired.

Programmers can address this concern by building explicit moral direction into their educational VE. This can be done in a number of ways. First, programmers can attempt to model in VE the negative consequences of anti-social actions in the real world. Second, at crucial points in the program they can add explicit references to the real world beyond the computer screen: by embedding video sequences, or explicit instructions to the user to consider the issues raised and discuss them with someone else. Third, programmers can consider limiting access to some parts of the program with parental-locking mechanisms, ensuring that parents or school staff must authorise and monitor their use. This option should be reserved for exceptional cases - for example, to prevent students from using a photo-realistic sex education VE merely for titillation.

These recommendations to programmers emphasise the responsibility of teachers and parents in providing both context and setting for students' exposure to media images, to assist them in arriving at appropriate interpretations. It is this that is perhaps the most fundamental ethical requirement for the educational use of VE.

Finally, we must consider the massive power of programmers to influence the virtual experiences of users. The ethical responsibility of VE programmers can be compared to that of town planners or architects in creating spaces which are more conducive to some kinds of activities than others. This issue is especially relevant when the intended users are students with severe learning disabilities, who are unlikely to have much involvement in the design process. VE for students with learning disabilities may also have therapeutic uses, in which case the ethical responsibilities of the programmer are analogous to those of a doctor or therapist. In all cases, programmers need to be aware that their creations are not value-free - as Boal (1995) observes, "technology is

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congealed ideology". Development of VE in close consultation with the intended end users or their representatives, parents or teachers -even devolving to them important decisions on content and structure - is the best way to ensure that programmers' power is deployed in ethically acceptable ways.

STAGE 5: The optimal design of virtual learning environments.

Empirical testing has aimed to establish the educational veracity of virtual learning environments and this has led us to believe that we could employ a similar process to help determine the optimal design of VE for the different 'types' of learning. This could help us to produce guidelines on the optimal construction of VE using current technology by investigating issues concerning complexity of virtual learning environments and the ensuing speeds of access, the use of scanned images, video sequences, embedded sequences and contextural three dimensional sound.

VE are now being planned and constructed composed of varying degrees of the above factors, to investigate how their relative presence in an environment might influence the transference of basic life and spatial skills to the real world. Also of interest is the dichotomy between the use of embedded sequences and scaffolding techniques in VE that, on the one hand offer total freedom and autonomy, whilst on the other seek to have control structures embedded within them so that important lessons will be learnt. For example, within the virtual kitchen it will only be possible to boil the kettle after filling it with cold water, or experiencing a limited degree of freedom whilst navigating to ensure that the student won't become lost or disorientated and thus experience a degree of frustration.

The use of three dimensional sound may be of help in virtual navigation exercises but perhaps a distraction when attempting to focus in on and learn selection and payment skills in a supermarket. If we try to replicate the buzzing and random complexity of the real world in the virtual city, it may look very realistic, but a student's ability to move through it and interact with it at a speed where they could generalise the lessons learnt there might be considerably hindered.

The development of guidelines for the construction of virtual learning environments will be a significant influence on the way be plan, develop and use them in special schools.

CONCLUSION

VIRART, the Shepherd School and the Department of Learning Disabilities at the University of Nottingham have described an emergent methodology to define a possible role for virtual learning environments in special education. As the LIVE project matures it has become clear that the VE we produce for use by students with a range of learning and motor skills difficulties are influenced by a set of five factors that act together to drive and shape not only individual learning environments but also the program as a whole.

A battery of tests has also been gathered and exploited to enable us to evaluate the methods which we use to define the LIVE program. It is this structured methodology that may help us to not only turn ideas into working programs in special schools today in an efficient manner but also share

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our findings with other groups working on defining the role of VE in special education and provide a framework for extending the use of VE into other areas, notably mainstream education and training.

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