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Developing Scaffolded Virtual Learning Environments for People with Autism

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Abstract

Virtual Environments offer the potential for users to explore social situations and experience different behaviour responses for a variety of simulated social interactions. One of the challenges for the VE developer is how to construct the VE to allow freedom of exploration and flexibility in interactive behaviour, without the risk of users deliberately or inadvertently missing important learning goals. The program has to be structured to guide the user in their learning and to take into account different levels of ability. This embedded 'scaffolding' within the VE software can aid the user's learning in different contexts, such as individual, tutored or group learning situations.

This thesis looks at the design and implementation of desktop VEs in a classroom for teaching social skills to people with Asperger's Syndrome (AS). The first part of the thesis looks at work carried out as part of the AS Interactive project, a multi-disciplinary research project using User Centred Design principles. VEs developed with the help of teachers and users were constantly refined in an iterative design process with evaluations and observations of the use of the VEs in the classroom to assess the effectiveness of elements used to scaffold the VEs.

The last part of the thesis looks at work continued by the author after the end of the AS Interactive project after recommendations in that project for the VEs to fit the needs of the individual. Individualisation is researched with a number of demonstration and prototype VEs developed to help obtain information from autism experts and teachers on how best to individualise a learning VE for people with autism.

The outcomes of this thesis include an exploration of the role of the programmer within a multi-disciplinary research group and the iterative development of VEs. A number of recommendations on how to scaffold VEs and make them usable in the classroom are then made. Finally recommendations are made on features and scenarios that could be useful in individualised learning VEs for people with autism and which require further evaluation in a classroom.

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The research in this thesis started out as part of the AS Interactive project, funded by the Shirley Foundation. This project group involved a large number of people and I would like to thank everyone involved, as much of the research in this thesis would not have been possible without their support. I would particularly like to thank Dr Helen Neale, who I worked closely with in the AS project.

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Chapter 1. Introduction

1.1 Background

Autism is a "spectrum" disorder, ranging from ' classic' autism with severe learning disabilities at one end, to high functioning autism (HFA) and Asperger' s Syndrome (AS) at the other. People with AS can excel in certain areas academically due to having normal cognitive levels, a narrow range of interests and sometimes, obsessive behaviour. However despite having good cognitive levels and personal life skills, people with AS often lack social understanding which can lead to social exclusion and failure to maintain employment due to difficulties in making friendships and communicating ideas (Strickland, 1997; Parsons et al, 2000).

It has been suggested that Virtual Environments (VEs) may be particularly useful for people with autism and may provide the ideal method for social skills training (Beardon et al, 2001). VEs are 3D environments developed using Virtual Reality (VR) which is defined by the Cambridge online dictionary as "a set of images and sounds produced by a computer, which seem to represent a place or a situation that a person can experience or take part in" (http://dictionary.cambridge.org). Eastgate (2001), simply defines VR as the technology used to create and present VEs, which in turn are computer generated, interactive 3D models. The definition used in this thesis is as described by Cobb and Stanton-Fraser (2005) as a combination of systems comprising computer processing (PC based or higher), a building platform for creating 3D environments, and peripherals such as visual display and interaction devices, that are used to create and maintain virtual environments. The shared features between virtual and real worlds may facilitate the generalisation of skills from the former to the latter. The main benefit of VEs is that users can practice skills safely, without experiencing potentially dangerous real world consequences and the interaction can take place without face-to-face communication which many people with autism find particularly confusing. In addition, the social complexity of the situation and the non-verbal and verbal features of communication can be directly controlled and manipulated (Parsons et al, 2000). Previous research has found that VEs empower children with disabilities by giving them a sense of control over their environment and allows them to actively participate and focus on their abilities (McComas et al, 1998).

However, there is no clear understanding of how well VEs support learning and when they should be applied, although some research has assessed whether intended knowledge or skill has been acquired by a user (See Cobb and Stanton-Fraser, 2005, for a review of specific learning objectives).

Possibly because the application of VEs to learning is still relatively new, research in the field has tended to focus on the design process, with most studies concentrating on user attitudes towards the technology and usability issues. Thus there is still little experimental evidence to show that VEs produce any learning gain. The few studies reported have examined varied types of applications, users and settings in which learning VEs are used and so it is difficult to generalise the learning outcomes of VEs (Cobb and Stanton-Fraser, 2005). While the learning of abstract concepts, which VEs offer, is difficult to measure using traditional measures of knowledge acquisition, skills training should be evident in a transfer to real world behaviour. Generally, studies have failed to demonstrate any transfer of learning due to small sample sizes and short research time scales, though studies such as the Virtual Life Skills project have indicated that given a longer period of testing, real world learning may be possible for some people with learning disabilities (Cobb, Neale and Reynolds, 1998; Brown et al, 1998).

Likewise, there is no single consensus about what learning theory underlies the effectiveness of VEs. This lack of consensus can be attributed to the versatility of VEs and the different ways in which it can be used. Moshell and Hughes (2002) distinguish between three types of learning activity supported by VEs: Constructivist learning via the exploration of pre built virtual worlds, Constructionist learning via students themselves creating or modifying virtual worlds, and situated learning via interactive role-play in shared or collaborative VEs (from Cobb and Stanton-Fraser, 2005). The most widely reported learning theory in the use of VEs is constructivism (Youngblut, 1998). VEs do appear to support the constructivist theory of learning (Neale et al, 1999), which advocates that learning environments should support student led exploration without instructing and prescribing activity, using case-based rather than predetermined sequences (Jonassen, 1994). Dick (1992) however argues that constructivism appears to place the responsibility for what is learned and how on the learner. This could give the user too much freedom and rather than learning effectively, they would risk making ill-informed choices for themselves. Dick goes on to say that important issues for educational VR lie between the two extremes of constructivism and instructional design, where learners are only provided with those strategies required for success in that domain. The Human Interface Technology Laboratory at the University of Washington, held a workshop to investigate whether VEs had any added value for students learning complex science topics (Winn, 1997). Whilst it was recognised that VEs provide students with the opportunity to learn by interacting at their own pace, concern was raised regarding how well students could use the VE to construct an understanding of the target learning objectives. It was concluded that allowing students freedom to explore a VE is not sufficient – learning requires guidance, feedback to actions and collaboration (social negotiation). Having this guidance and structure is particularly important in teaching students with autism, as consistency, predictability, stability and simplicity are required (Autism Society of America, 2001).

The guidance and structure used in learning VEs is described in this research as 'scaffolding'. This is defined as a metaphor to illustrate how a large amount of structure and guidance may be required to start with and especially for users of lower ability and how this scaffolding is dismantled by removing help as a user's ability improves.

1.2 Research Principles

The research discussed in this thesis applied the principles of User Centred Design (UCD) to construct virtual environments for students with Autistic Spectrum Disorders (ASDs) to learn social skills. A multidisciplinary team of domain experts (teachers and autism professionals), software designers, psychologists and human factors experts worked together throughout the design lifecycle to ensure the application was robust, useful and usable. UCD focuses on the needs of potential users from the very beginning and this integrated research approach allows specification for VE design to be informed by user needs and requirements whilst taking into account characteristics and limitations of VE technology (Cobb, Kerr and Glover, 2001). An iterative development process is then established which allows further design developments to be informed by user review and professional evaluations of the system (Neale, 2001).

In many UCD projects, the technology expert (in this case the programmers) are often given a set of instructions or design guidelines by human factors or domain experts who do not understand what can be done with the technology, particularly in a finite time span. Similarly, the technology expert may not understand enough of the human factors requirements to make them a priority (or include them at all) in the system development as 'getting it to work' is the first priority. It is vital therefore that these two groups communicate effectively throughout the design and development life cycle. While advancements in both computer technology and software mean that there are fewer hurdles to overcome in developing a program which fulfils the users requirements there are still some technical limits as well as limits on what can be achieved in a given time. These advancements can also lead to the propensity of the development to be centred around pushing technical boundaries and it is easy to lose sight of maintaining the design in a user centred manner.

When designing any specialised application such as for people with autism and in this case, specifically Asperger's Syndrome, developers need to be particularly aware of usability issues. Programmers used to designing applications for a neuro-typical user group where they can rely a lot on their own experiences (thinking of themselves as 'normal') may try a similar approach to a special needs group. By imagining themselves in the position of the user, they may feel they understand the issues they face when in fact they probably do not. To avoid this uncertainty then the target users must be consulted throughout the development. The involvement of AS users in the prototype design stage however may not be straightforward, as they might find it difficult to express what they need. It is therefore essential to involve autism professionals and teachers to help inform the design of the prototype which then can in turn be evaluated with the users to engage them in ideas for evolving the application in the next phase of the development cycle.

1.3 Aims & Objectives

This thesis presents research carried out as part of the AS Interactive project, a multi-disciplinary project involving a team of VE developers, psychologists, human factors researchers, teachers and Autism Training Consultants, to develop single user and collaborative virtual environments for adolescents and adults with Asperger's Syndrome to learn social skills relevant to social interaction in public situations (Parsons et al, 2000). Whilst the broader aims of the AS Interactive project were to develop and evaluate the use of different types of virtual environments to support and enhance social awareness and social skills amongst adults with AS particularly in preparation for the work environment, the author was primarily concerned with one aspect of the overall project. The goal for the author and therefore the main aim of the research discussed in this thesis, concerns the design and development of the VEs themselves, taking into account users with ASDs. To achieve this aim and develop effective VEs for learning, it was necessary to examine how learning can be supported and how VEs would be used in a classroom setting. Issues of usability and interface design were important as it was not known how users with ASDs would interpret and understand VEs.

Therefore, a number of specific research questions have been explored;

1. What is the role of a VE developer in a multi-disciplinary design process?
2. How can VEs be made usable to support learning for people with ASDs?
3. How can VEs be scaffolded to support learning in the classroom?
4. How can learning VEs be programmed so that they are robust and scalable?

To obtain answers to these questions requires the author to research and understand the needs of the user, exploring the technological and teaching capabilities of single user VEs to determine what features of VR are beneficial to teaching people with ASDs. This was done in part with the collaboration of a multi-disciplinary research team and this thesis will look at how the VE programmer fits into this team. Not only must the VEs meet the needs of the user in terms of learning and usability, they must be *used*. In other words, there is no point in developing a functional, usable piece of software if nobody uses it. An objective of this research therefore was to examine what issues both internal and external to the software are required to ensure an uptake of the VEs in schools. Evaluations and observations of the use of the VEs in schools can help the developers understand some usability and utility issues which otherwise would not be discovered until later when rectifying these errors may prove difficult. If a wrong design path had been undertaken for a long period, any significant changes to be made to the VEs might be extremely awkward or time consuming. Continual iterative refinements and testing ensures the program is robust and usable which is particularly important when the end users behaviour in using the system can be quite unpredictable. Usability and utility issues are partly determined by a user's ability to use the VE and so in turn is affected by the scaffolding within a VE to aid learning. Observation studies allow the author to investigate the scaffolding required within VEs to facilitate learning, ensuring usability and meeting individual needs. Scaffolding can be examined to see how best to guide users through learning scenarios, both explicitly and implicitly, e.g. telling users what to do and automatically moving them or subtly guiding them by the availability of options. The level of scaffolding for different levels of ability and how this is achieved within the program is also researched.

1.4 Overview of the AS Interactive Project

1.4.1 Overall Aims

The research in this thesis was initially carried out as part of the AS Interactive project which ran for three years, culminating in April 2003 and was funded by the Shirley Foundation. The aims of this project were to develop a range of virtual environments (VEs) which could be used for teaching social skills to people with Autistic Spectrum Disorders (ASDs) particularly aiming to help them within the workplace. The approach to the project was generally as follows;

1. Examine the suitability of VR technology for people with ASDs
2. Design and develop VEs for social skills training
3. Evaluate use and usability
4. Evaluate effectiveness

Initially it was planned to have two different types of VE, a single user virtual environment (SVE) and a collaborative virtual environment (CVE). The SVEs would be applications in which a user is guided through a social interaction task and invited to make choices about what to do and what to say in specific situations. The user may be supported by a teacher or training advisor seated next to them at the PC. The scenarios have different levels of social complexity through which the users progress. Training scenarios include:

- Queuing for food in a virtual café and then finding somewhere to sit.
- Queuing at a bus stop and then choosing a seat on the bus.

CVEs are where several users, positioned at different PCs, can simultaneously share the same environment. Each user is embodied by a virtual character or avatar of their choice. Users navigate around the 3D environment and speak directly to each other using a microphone and headphones. The teacher or training advisor may support users by taking the role of one of the characters within the CVE. Training scenarios include:

- Informal café scenario
- Formal job interview scenario.

1.4.2 Project Team

The project team was multi disciplinary and based at the University of Nottingham with autism specialists from The National Autistic Society (NAS). The group’s roles were as follows:

NAS:- Provided guidance on user needs and appropriateness of application design. Helped evaluate applications and provided support and contacts for user groups.

Psychology:- Provided some background research on the nature of autism and learning to inform project requirements and investigated specific issues such as whether people with AS could understand that the VEs represented the real world, their perception of personal space in the VE, the understanding of interaction metaphors and the transfer of learning.

Computer Science:- Concerned with the development of the CVE in parallel to the SVE, with a more technical slant as focus was getting the application to work rather on its usability, although user issues were taken into consideration as far as possible.

VIRART:- Itself a multi disciplinary team which creates Virtual Environments based on User Centred Design and usability evaluations. There were three members of VIRART working on this project, two human factors experts focusing on overall project design and evaluation through UCD and the author as sole programmer of the SVEs.

1.4.2.1 VIRART and Role of Author

Established in 1991, the Virtual Reality Applications Research Team (VIRART) is based in the School of Mechanical, Materials and Manufacturing Engineering at the University of Nottingham. VIRART is a multidisciplinary, independent, research and development group with expertise in ergonomics, manufacturing engineering, computer systems, psychology, operations management and computer aided design. In conjunction with the Institute of Occupational Ergonomics (IOE) it carries out substantial research into design and evaluation of VEs and VR technologies. VIRART takes a user centred approach to the specification, design, development and evaluation of VEs in both industrial and educational applications development. Participatory design methods are used at the specification and design stages to ensure that user needs and preferences are taken into account. A significant area of VIRART's research is in the development of VE building techniques. Initially based on HCI theory, these techniques have been developed through experimentation and extensive evaluation of VE design. Evaluation of VEs involves experimental assessment of usability issues and effectiveness of VE use (e.g. success of transfer of training). A large programme of research has also established methods for the evaluation of the effects experienced by users, including feelings of presence, physical and cognitive ergonomics issues and health and safety issues. This research has been used to aid the development of guidelines for VE design and implementation (www.virart.nott.ac.uk). The author has worked with VIRART since 1995, designing and developing VEs for special needs education, mainstream education, industrial applications and industrial design, utilising technical knowledge with a background in Human Factors.

The role of the author in the AS Interactive project was in the design and development of the SVEs. The author, while the sole programmer of the SVEs, also has a background in human factors and so was uniquely placed to provide a bridge between the theoretical design and practical application. Autism professionals, psychologists and human factors experts collaborated on the content of the learning scenarios and produced storyboards for these. The author along with other human factors experts then collaborated to produce initial interface designs and interaction metaphors. The author then had the sole responsibility of programming the SVEs in a structured way, which would support learning by providing guidance, both seen and unseen, to the user to help them achieve their goals. To help achieve this, the author researched learning theory and the nature of autism with specific regard to learning software and design issues. Evaluation of the SVEs in terms of usability and educational value was the responsibility of those members of the project dedicated specifically to this task as the special needs of the users required specialists to help with the evaluation studies, but the author was closely involved in evaluation studies as part of the iterative development and design cycle.

1.4.3 Development Phases

The design-development cycle of the SVEs can be effectively split into three phases.

Phase 1: The prototype SVE was the café scenario in which the user has to find a seat to sit down. A training scenario was developed alongside this to teach the user the different interaction metaphors. There were four levels of difficulty in this SVE, taking the user to a point where it was considered best to then move to a CVE, which would allow for greater communication and social interaction between people. The author's research involved looking at the differences needed in code structure for increasing levels of difficulty and flexibility and at what point it was best to proceed with a CVE from a programming perspective.

Phase 2: A new scenario was developed where a user had to find a seat on a bus, therefore having the same task as the café scenario but in a different context to help promote generalisation. Changes were made to the interface and scaffolding of the environments following feedback from the first phase. There were then a series of user trials at Rosehill School in Nottingham, which further refined the applications.

The author was present at the user trials, observing the use of the application to see where improvements could be made to:

1. improve the robustness of the software
2. improve its usability
3. improve the scaffolding to support learning
4. make it suitable for use in a classroom situation

The author observed these trials and the sessions were video taped to analyse later. Human factors experts and psychologists were also present at these trials, though they of course were looking at them from their own perspectives and research needs. There were also a number of informal sessions with user groups in Sheffield and Leicester, which the author attended where community based, autistic, social groups had the chance to try the SVEs out and give their comments.

Phase 3: This phase was conducted in the year following the official end of the 3 year AS Interactive project, though remaining funds from this project were used to continue the investigation. Findings from phase 2 highlighted a new need and that was for the learning scenarios to be individualised to meet each user's specific needs. The author researched individualised software and adaptable learning programs before producing a prototype application based on the café scenario. This included investigating what differences, if any, were needed in the programming of such environments, the features required for it to be usable and scaffolded before getting feedback from autism teaching professionals on its validity.

1.4.4 User Studies

Rosehill School is a school in Nottingham for people with AS and early evaluations involved using the SVEs as part of the student's group sessions. So the software was set up at the school and a number of informal sessions were recorded to look at how the software was utilised in a class environment and what issues needed to be addressed to improve its overall utility. The session groups consisted of between 8 and 12 male students from the 16+ age group, two teachers and some carers. A discussion of results from these studies is given in section 2.6.2. Additional studies were carried out at a number of other schools (Foxwood, Brackenfield and The Bluecoat Schools, all in Nottingham.), both special needs and mainstream, but these were investigating areas not directly related to the author's work, and so are not presented in this thesis (see Parsons et al, 2004, for details of these studies).

While the learning SVEs were concerned with social skills learning for people with AS, the work of the author does not concentrate on social skills learning or what makes a good scenario for teaching, but rather on the design and construction of a software tool that allows both a user to interact with the scenarios successfully and for the teachers to be able to utilise the program as part of their lessons in a manner they see as beneficial to the students and beneficial to their job. In researching learning environments for people with AS however, the author gained a lot of knowledge about the needs of people with autism and was able to utilise this knowledge into the SVE designs and not just rely on feedback from evaluations with no real understanding of why an element of the software did or did not work.

Literature areas reviewed as part of the author's research was as follows;

- Autism / Aspergers Syndrome
- Constructivism / Learning models
- Learning VEs and CVEs
- Psycho-Social Issues in Developing VEs
- Embodied Interaction in Social VEs

From this review, information was gathered on;

- Autistic needs
- Educational needs
- Educational Solutions/models
- Technical needs
- Solutions for VR
- Autism Software Issues
- Practical Issues of using software in classrooms
- Teacher Agents/Scaffolding

1.5 Specific Contributions of the Author to the Project

The following describes the role of the author within the AS project involving the design and development of the café and bus VEs described in Chapters 4 and 5. The individualised café VE described in Chapter 7 was completed after the main body of the AS project had finished and was primarily undertaken by the author in all areas of development with input from teachers and autism professionals according to UCD principles (section 3.5).

Meetings – The author was involved in most meetings of the steering group involving all members of the development team as well as autism experts and psychologists, especially when discussions had implications on the design of the SVEs. Being present at these meetings allowed the author to understand the needs of other members of the AS project team as well as explain how things could be done in the VE and any limitations resulting from the technology. This was particularly effective when brainstorming ideas about what could be included in the learning VE experience. The author was also involved in smaller design meetings with the rest of the development team.

Design – The content of the learning scenarios and the interactions that the user would be expected to make were decided by other members of the project team. The author was involved in how to turn these storyboarded ideas into a working, usable, VE that was scaffolded to aid the user in their learning. These decisions were of course made as part of the team with other members commenting on these ideas or making new suggestions. The interface to the VE was also designed by the author with the help of the development team, using the author's experience of designing similar interfaces for earlier VEs with other members more closely involved with the content of the learning scenarios, AS research and the evaluators in the team.

Evaluation – The author's principle role here was in the observ ation of the use of the VEs within the classroom as well as meetings and discussions between other members of the project team and teachers when assessing changes as part of the iterative design process. Formal usability evaluations on the overall system, specific areas of the interface and the suitability of the technology for use with people with AS was carried out by the human factors members of the development team and those from psychology.

Programming – The author was the sole programmer of all single user learning VEs described in this thesis.

Research – The author conducted his own research into the use of VEs for teaching social skills to people with autism regarding their capabilities and functioning, specifically regarding the type of help they would require to carry out the learning tasks effectively (scaffolding). This allowed for informed decision making and not relying solely on the input of other researchers. This research is described throughout the thesis though particularly in Chapters 2 and 6.

1.6 Structure of the Thesis

This thesis follows a chronological path detailing how the research progressed from need to initial prototype through understanding user requirements to the next few design iterations with each chapter building upon the previous one. This allows the explanation of how the research evolved as this process went along. It includes both design guidelines drawn from autism experts, literature and user studies as well as technical guidelines and considerations in programming the VEs. Most importantly though is that it is all centred around a practical rather than theoretical framework, showing how such an application can actually be used.

Chapter 1 introduces the reader to the thesis, explaining the need for the research, an overview of what was carried out and the contribution of the author to the multi disciplinary project and research carried out specifically by the author.

Chapter 2 looks at learning paradigms and learning in VEs. In particular specific learning issues relating to people with autism as well as theoretical design guidelines are investigated. Scaffolding of learning programs and how elements in other applications similar to ones in the applications developed in this research are also investigated.

Chapter 3 discusses the methodology of the research, justifying its use and explaining how design decisions were made from one phase to the next.

Chapter 4 describes the initial phase of development of the SVEs. Starting with identification of requirements from user studies and teacher workshops, the chapter outlines the development of a prototype café VE. Observations of the use of this prototype VE in schools as well as formal evaluations carried out by other project members are also reported, leading to recommendations for the continued development of the SVEs in the next chapter.

Chapter 5 builds upon findings from the previous chapter, looking at the next stage of development, which include adaptations to the café SVE as well as the development of a new bus SVE and new learning scenarios. Final observations and changes to the VEs as part of the AS Interactive project are reported along with how the code is structured within the VEs.

Chapter 6 builds on previous findings, which point to the need for individualising the learning software and investigates the new requirements and the shift the research needed to take to fulfil the initial objectives. Demo VEs of new scenarios are discussed and presented. These were used to demonstrate some individualisation features to autism professionals to facilitate ideas and requirements for individualised learning VEs for people with AS.

Chapter 7 shows how a prototype individualised SVE was developed for the café scenario based on feedback from autism professionals. The flexibility of the code to allow individualisation is discussed before finishing with a review of the prototype by teachers, assessing its potential for them and their students.

Chapter 8 summarises the general findings of this research and discusses the implications for the development of learning VEs for people with AS. It goes on to recommend guidelines for designing structured learning VEs in line with the aims of the project as well as guidelines for the development process in general. Recommendations for future research are then presented.

Chapter 9 concludes the thesis, listing the author's contribution to the main research objectives as well as wider perspective contributions, before listing recommendations for future work.

Figure 1-1 shows a breakdown of the following chapters and as can be seen they can be effectively broken up into four pairs with the first pair of Chapters 2 and 3 looking into what should be included and why into a learning VE for social skills training and how this should be accomplished. The design, development and testing of the level based café and bus VEs are then illustrated in Chapters 4 and 5 before the requirements for an individualised VE and the development of a customisable version of the café VE are presented in Chapters 6 and 7. Finally a discussion of the thesis and resulting conclusions are presented in Chapters 8 and 9.

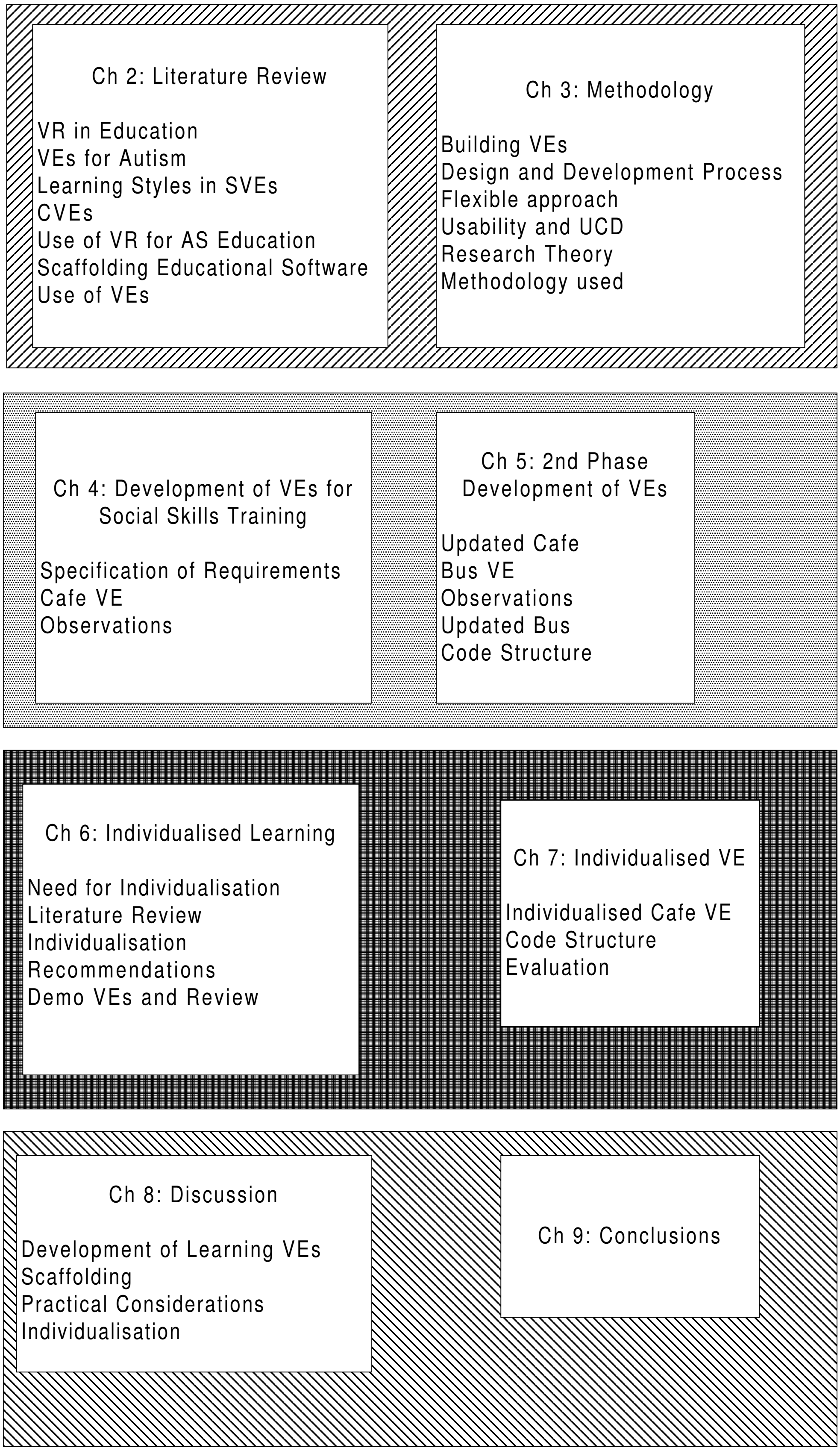


Figure 1-1: Chapter Outline

Chapter 2. Literature Review

2.1 Introduction

Task-orientated jobs in Information Technology and data processing can provide people with Asperger's Syndrome (AS) and other Autistic Spectrum Disorders (ASDs) an option to maximise their potential at work. People with high functioning autism are extremely good at jobs with computers (National Autistic Society, 2001). While people with autism can work effectively with computers, social interaction is difficult for them, which could cause problems at work even if they spent most of the time working on a PC. Computers could therefore offer the potential to facilitate the learning of social skills to a degree that would be helpful in the workplace. Virtual Environments (VEs) and Collaborative Virtual Environments (CVEs) are seen as being particularly useful for people with autism and may provide the ideal method for social skills training (Beardon et al, 2001).

This chapter begins by looking at the characteristics of learning in VEs and the attributes of VEs that facilitate learning styles that may be conducive to teaching people with autism. While single user VEs (SVEs) and CVEs are different in principal, issues relating to CVEs are also discussed as they can be relevant, especially when the context is social skills learning. This is because both types of VE can support communication with other characters, although in an SVE these characters are controlled by the program and not another user. As this thesis is based on a user centred design approach, factors relating to issues faced by people with autism and teaching strategies used for them are then discussed before looking at how VEs can be designed to cater for these factors. Following this, literature relating to structuring or scaffolding educational VEs for people with autism is reviewed. The chapter concludes with an overview, highlighting some of the areas of research that this thesis will investigate. It should be noted that more literature is reviewed at the beginning of Chapter 6, relating specifically to individualising software. This literature review is directly applicable only to research detailed after Chapter 6 and was not identified as a requirement until later in the VE development process.

2.2 Virtual Reality in Education

It is generally agreed that there are several characteristics or attributes that set VR apart from other types of media and reasons why it lends itself to being a unique and potentially very useful educational technology. Crosier (2000) suggests that the characteristics of VR for education can be divided up in terms of those relating to VR – the technology as a whole - and those relating to the VEs – the specific three-dimensional worlds created using the technology. In this section, the attributes of VR will be discussed while the attributes of VEs for education and specifically for people with ASDs will be looked at in section 2.6.2. Firstly, to help illustrate attributes of VEs by their current use, examples of VEs and their use in mainstream education shall be discussed.

2.2.1 Use of VEs in Mainstream Schools

Despite all of the research that has gone into educational technology and Computer Aided Learning (CAL) and for all the enthusiasm that has been shown for VR as a potential new educational medium, there have been relatively few actual applications developed for use in schools (Crosier, 2000). Crosier (2000) also concludes that the majority of VEs used in schools are used to teach science subjects, citing Christine Youngblut's (1998) survey into the educational uses of VR technology. This is due to science subjects requiring either abstract thought for many theories as well as the inherent danger of performing lab work in certain scientific topics. This prompted Crosier herself to develop and evaluate a VE to teach about the radiation emission from different materials and the effect that other materials had on blocking this radiation in the RadLab application. More recently Jensen et al (2004) report on CoVASE, a toolkit to develop educational visualization and simulation environments for students, researchers, and tutors in the natural and engineering sciences in a rapid way, while Shin (2002) reports on VEs developed to teach science concepts such as radiation balance, earthquake waves, the earth's crust balance, the movement of the ocean, and the solar system at the level of middle school. Trindade et al (2002) discuss a number of pilot studies to examine virtual reality's potential in education; *ScienceSpace* is a series of virtual environments to assess the potential impact of VR in science education, *VriCheEL* is a VE to explore chemical engineering and *Chemistry World* is a virtual environment in chemistry.

While the majority of educational VEs in mainstream schools are directed at teaching science subjects, the attributes of VR technology must surely be able to offer other educational opportunities. Sala's (2003) review of multimedia technologies in the educational field in different kinds of schools indicates it can be used in different ways;

- to support traditional educational methods
- to help distance education in different kinds of schools
- to create a constructivist learning environment
- to help remote training in the field of the electronic instrumentation
- to realize a multimedia archive of information available online

So what are the attributes of VR that make it an ideal tool in education? These are discussed in section 2.2.2.

2.2.2 VR Attributes

"*Developing educational visualization and simulation environments (virtual labs) is hard, but, they are worth the effort because they support self-driven learning*." (Jensen et al 2004, p2148)

Poland et al (2003) conducted a qualitative study on how to incorporate interactive multimedia science software into the classroom, and observed a growth in various social and thinking skills that were developed and reinforced within the computer-supported learning environment. Several factors that contributed to these learning outcomes were identified, such as instructional design features, enthusiasm, on-task behaviour, cooperation and collaborative learning among students, attitudes towards science and the teacher's approach towards incorporating technology into the curriculum. They also state that enjoyment is an important aspect of learning, increasing attention span, motivating individuals and making something more memorable.

Trindade et al (2002) and Sala (2003) report on 3 factors that are important in VEs facilitating the formation of conceptual models, these being Immersion, Interaction and Engagement. Crosier (2000) however describes 5 factors; Presence, Real Time Interaction, Learning Style, Flexible Teaching Tool and Motivation.

2.2.2.1 Presence

The user should be able to interact with the VE in a way that reflects how they would do this in the real world. If the interface is designed well, the user is then able to suspend their disbelief and think that they are present in a Virtual World. Wilson *et al* (1996) define presence as "the sense that somebody has of *being there*". Winn (1997) suggests that presence might be associated with enjoyment, the ability to navigate and perform tasks and even with learning. His study showed that those students who learned more from using VR also reported a high level of presence (Winn, 1995).

2.2.2.2 Real-time Interaction

Interaction in real time encourages active participation on the part of the user and ensures that learning can take place at the user's own pace. Salzman *et al.* (1995) explain that students can actively control the environment and directly experience the behaviour of objects in the virtual world. Real-time interaction also allows the user to experiment with "what happens if" scenarios (Brown et al, 1996) and employ trial and error strategies in learning, allowing users to investigate different situations and go back over items or activities that they are unsure of.

2.2.2.3 Learning Style

That VR facilitates many different styles of learning is believed to be its most powerful asset (Byrne et al, 1995). Winn (1995) believes that VR takes advantage of visual and kinaesthetic abilities and learning strategies that are less likely to be used by students in more traditional, symbolic modes of instruction. VR also reduces the need for abstraction or the understanding of complex symbol systems (Osberg, 1992).

Early in the development of VR, benefits for education were predominantly considered to be the experiential nature of VEs and the facility for hands-on learning and learning by doing. Shin (2002) also states that VR technology may be useful for learners who are visually orientated, while Jensen et al (2004) believe VEs can help students to;

1. apply social skills to mutually help each other when problems occur and to achieve common goals,

2. test their collaborative problem solving abilities by use of ill-defined contextual information, and

3. acquire technical skills to use visualization software.

They conclude that preliminary evidence shows inspecting 3D visualizations can improve learner satisfaction due to the vivid presentation, and at least maintain learning efficacy. Content must not distract from the learning objectives and must provide clear views that leave students little space for misinterpreting data. However, how interactivity, collaboration, and content design, influence each other with regard to learning performance, satisfaction, and comprehension in courses requires further investigation.

2.2.2.4 Flexible Teaching Tool

There are many different types of VR system, which means that the technology is quite flexible in terms of use. Even within each type of system there is flexibility in how it can be used in the classroom. For example desktop systems can be used individually or in small groups. The technology is also flexible in terms of the variety of Virtual Environments that can be developed. For example VEs can be created which provide additional support in a particular subject, or environments can be created that can teach an entire course (Crosier, 2000). As Bricken (1991, p180) points out, VR "*provides teachers and trainers with an enormous variety and supply of virtual learning 'materials' that do not break or wear out*." Bell and Fogler (1997) report however that while VR can benefit some students in some situations, when it is properly implemented, the implementation itself is not straightforward, and VR should not be considered as a replacement for real experiences when the latter is available. VR should be used as a supplement to real experiences, and/or situations where the real experience is inaccessible.

2.2.2.5 Motivation

"*The motivation to learn hinges on interest, and most people find VR a very interesting experience*." (Bricken, 1991, p179).

In his studies using primary school children learning about 3D shapes, Ainge (1997) found that those children who tended to be reluctant to participate in classroom activities maintained their enthusiasm over a period of six weeks when using VR. A comprehensive study by North (1996) confirmed that the virtual reality experience stimulates learners' motivation, comprehension and interest for a longer time than the same experiences in the real world. Byrne *et al* (1995) used VR with students who had dropped out of mainstream schools and observed that they became more engaged in school and showed more enthusiasm. More recently Trindade et al (2002) concluded that students with high spatial abilities had an increased conceptual understanding by using VEs while being more highly motivated to learn and Sala (2003) also suggests that educational applications may benefit from VR because they can increase the student's engagement and motivation.

2.2.3 Usability Studies

The usability of a VE is naturally of great importance in an educational setting. A VE that is difficult to interact with can adversely affect the virtual experience in terms of motivation and learning outcomes (Crosier, 2000).

There are a few studies that have set out to evaluate the usability of educational VEs, though many have centred around hardware interface issues rather than on content. A study by Bricken and Byrne (1992) used observations and a survey to collect usability data with 59 students, predominantly male, between the ages of 10 and 15 yrs old. The head-mounted display was found to have a low resolution that rendered it inadequate for object and location recognition, and the glove used for manipulating objects in a supposedly more natural way, proved not to be a very natural method of interaction at all. Dede et al. (1996) in their evaluation studies, measured usability for both an immersive VE and a 2D computer. They found a number of usability problems, with findings indicating that participants found the immersive environment more difficult to use. The 3-Ball and virtual hand, which were used as input devices, were found to be particularly difficult for the users to master. Roussos et al, (1999) noted problems for young users with stereo glasses used in a CAVE system, as, in spite of adjusting mechanisms, they were too big and had to be held on, which contributed to fatigue and a lack of motivation.

Usability issues have also been raised as a result of other non-usability based evaluation studies (Crosier, 2000). Grove (1996) found that forcing real-world constraints on the VE, for example collision with objects, caused confusion due to the lack of tactile feedback and limited field of view, in other words the participants could not see or feel the object with which they had collided. Brna and Aspin (1997) also noted problems with restricted view, particularly for desktop systems, when moving around in the VE. In their example, participants were required to look at a moving ball from different perspectives, but found that participants could not "keep their eye on the ball" while moving into a suitable position. This leads to a major issue in VE development regarding the trade off between realism and usability. As Grove (1996, p6) points out; "*the assumption is, that because VR is like reality, then the learner will instinctively know how to interact with the computer in a meaningful way. However, in its present guise, VR (both immersive and desktop) is only a little like reality*."

We cannot produce situations which are "real" enough for participants to instinctively know how to interact with them as the peripheral devices – both display and input devices – interfere with the experience. The option for most VE developers, until the technology becomes more sophisticated and the interface is less of a barrier, is to treat the VE as another, albeit richer, computer interface and apply existing HCI knowledge, models, criteria and methods (Wilson et al, 2001).

2.3 Review of Existing VEs for People with Autism

Computer-based technology has been widely applied in autism training and it has been reported that computer systems offer many attributes that suit the needs of users with autism (Murray, 1997; Moore et al, 2000). Though widely used, there are still relatively few software applications for teaching people with autism and most of these are multimedia based 2D programs for teaching things like facial expressions or joining queues. The following are examples of this software, the first four being listed by the National Autistic Society (NAS)*;

1. *Boardmaker and Compic (www.compic.com) for teaching picture symbols to help develop communication skills.
2. *Fast ForWord (www.fastforword.com) for language training skills.

3. *My Friend Ben (www.asilesp.com) for social skills training.
4. *Smart Alex and Gaining Face (www.ccoder.com/GainingFace/) for teaching facial expressions.
5. David Moore at Leeds Metropolitan University has supervised the development of 2D multimedia software for teaching vocabulary (What Comes Next?), decision making (John's Journey, Johnny's World), emotions (NVC), body language and geography, utilising video clips, photos, graphics and sound. (www.lmu.ac.uk/ies/comp/staff/dmoore/software.html)
6. Click for Autism (www.r-e-m.co.uk) comprises a set of five 2D games covering visual-motor control, memory, ordering, forced choices and further choices.
7. Autism Online (www.autismonline.org/edusoftware.htm) offer three CDs to teach vocabulary and social skills at school e.g. teasing, bullying and making friends. Program uses text and movies to tell a story.
8. My School Day (helpingtogrow.istores.com) uses real life video to take the child into a typical school day, including the classroom, cafeteria, and playground
9. Autism Coach (www.autismcoach.com/Software.htm) offer 80 titles to improve key cognitive skills, language and social skills using predominantly 2D video based programs.

Very few Virtual Reality applications have actually been developed for people with autism, despite speculation that Virtual Environments (VEs) may be particularly useful for people with AS in social skills training although many have examined the potential for educational VR applications for this population (Clancy, 1996; Moore et al, 2000).

Kijima et al (1994) provide an early description of the use of Virtual Reality Technologies for autistic people. 40 individuals (children and adults, some with autism) were presented with a virtual representation of the Sand Play Technique, a psychotherapy tool used for the assessment and treatment of people with autism. In order to minimise the stress and discomfort of the participants in this study, a large screen display and 3D mouse was used instead of a headset and data glove input device. They were allowed to choose the background setting, avatar, and select their desired colour from a colour panel. They used a ' wand' to select and release objects and during play any figure near to the position of the wand would be highlighted to indicate that it could be manipulated. It was found that VR technology could find practical applications in clinical medicine, particularly in the diagnosis of autism patients.

The most well documented work was carried out by Strickland (1996, 1997) who carried out informal trials of headset-based VR with a small number of children (ages 7 to 9) with ASDs and learning disabilities. The aim of the study was to determine whether children with autism could respond to VR and if they might benefit from VR's controlled and limited representation of reality, in which events and stimuli experienced by the user can be strictly governed. It was found that the children could respond to stimuli in a VE and one child did learn a new skill (to stop at a stop sign), but due to the low language abilities of these children little in depth knowledge was gained about their feelings about the experience. Strickland also noted that many children with autism object to hats or helmets being placed on their heads, and so special attempts were made to acclimatise the children to wearing this headgear. One child took three sessions (of 15 minutes) before he would accept the helmet, and sweets had to be used as enticements, but overall the helmets were not popular at all. Desktop environments would solve this problem and can still give a feeling of subjective immersion, especially for visual search tasks (Robertson et al, 1993) as well as be more cost effective if the system is to be widely adopted.

In 1996 the Virtual Reality Applications Research Team (VIRART) co-developed 'AVATAR' a set of VEs for autistic children (Enyon, 1997). They allowed children to explore a 3D environment and interact with objects that included a sound effect and visual/verbal reinforcement. Trials with autistic children and their teachers found that participants could attentively focus on activities and gain meaningful interaction with the program, but evaluation was limited and results originated mainly from teacher comments based on one session of use.

Since these early investigations into educational VE applications for people with autism, little has been reported about research in this area. However, the Hypermedia and Digital Libraries (HYDILIB) Research Group, at the University of Athens are conducting a research project entitled 'Education and communication for children with autism' (Charitos et al., 2000). This project aims to develop interactive environments for the assessment and education of autistic children. An interactive 3D scenario has been developed using Virtual Reality technology that aims to address visual perception issues. A virtual character is followed around the VE and demonstrates a series of everyday activities allowing the participant to interact with certain objects. The technologies have so far been tested with educational technologists, but no formal evaluation study has yet been reported.

2.4 Learning Styles in Single User VEs

Many learning VEs today are single user environments where a person' s interaction will be with objects or virtual humans that have pre-programmed attributes and responses as opposed to responses in collaborative environments by real people, which are infinitely random. This allows the SVEs to be structured and controlled in a manner which can aid learning. Shin (2002) reports that VEs facilitate constructivist learning activity with some evidence of increasing student interests, understanding and creative learning. Education through gameplay is another learning style which is believed to have common traits to constructivism (Rieber et al, 1998). Researchers have highlighted the advantages of computer games relating to education, for example, Boyle (1997) notes that games can produce engagement and delight in learning. This section looks at constructivist learning theory and why VEs can be used with this paradigm as well as similarities of learning VEs with 3D games.

2.4.1 Constructivism - Structure

Constructivist theory advocates that learning environments should support student led exploration without instructing and prescribing activity, using case-based rather than predetermined sequences (Jonassen, 1994). If users are completely free to move about an environment and interact with any object or person and in any order they like, then vital learning goals may be missed without structure to the VE. In other words, there needs to be a balance between allowing a user to determine their own learning path and the order in which learning tasks are attempted, but have structure within the tasks where necessary to ensure the learning scenario does not disintegrate completely. A simple analogy is a dog on a very long lead, where the dog might feel it can go anywhere and do anything, but is in fact under a watchful eye and can be brought under control if necessary. Taylor (1996) looked at the introduction of interactive multimedia maths programs in two secondary schools and while the programs aimed to foster independent learning, she found that students responded to structure and did not want to jump around the environment too much. Left to their own devices, students may not be capable of self directed learning if their level of ability is low to start with. Students therefore should be able to choose which learning objectives they undertake at a given time and at a pace they find comfortable possibly with guidance from a teacher to make sure that their learning goals are met. This approach was one successfully taken in the Virtual City project (Neale et al, 1999), where users could navigate freely around a house or choose to go outside to catch a bus to either a café or a supermarket. Once a scenario had been chosen, the user would then be guided through a number of sequences to complete a task, before moving on to either repeat the same task or to try something different. Flexibility is offered in that the user had to choose which scenario to do at any time and if they wanted to repeat it, e.g. in a café scenario the user can decide which table to go to and when there decide if they want to sit there or not. Structured learning was provided by the design feature that when the user has activated a certain scenario only certain interactions or movements are available until that scenario is completed.

Another example of constructivist teaching through computer technology is reported by Sala (2003), *The Adventures of Jasper Woodbury,* a videodisk program for teaching math that was developed by The Cognition and Technology Group at Vanderbilt (CTGV). *Jasper* consists of four adventure stories designed to provide students with real-world, open-ended problems that do have correct mathematical solutions. CTGV believs that the realistic nature of Jasper problems (including their complexity) helps students construct important sets of ideas and beliefs and refrain from constructing misconceptions. Poland et al (2003) also describe how a shift in learning style from a transmission pattern to a more constructivist one, with problem-solving and research orientation was observed with students and teachers using interactive computer technology. The constructivism was reflected in factors such as a major increase in discussion and peer interaction.

2.4.2 Games

2.4.2.1 Learning in games

The structure of learning in VEs is similar to the modular organisation of games where the user can make mistakes which halt play, but in which typically the user can begin that level again (Jones, 1997). Sala (2003), reports that VR is connected to video games that have become part of children's culture. Educational applications may benefit from the technology of virtual reality games, which can increase the students' engagement and moti vation. Hence many researchers have highlighted the advantages of computer games relating to education. For example, Papert (1993) point out that video games teach children that some forms of learning are fast-paced, immensely compelling and rewarding. Boyle (1997) also notes that games can produce engagement and delight in learning. The games represent one way in which learners can be introduced into constructivist micro worlds, since users do not just study a particular domain but become part of the scenario. The successful games designer also rigs scenarios, so as to lead people to ideas and force them to confront and understand them (Norman, 2001).

Katsionis and Virvou (2004) report that there are several researchers who encourage the entertaining aspect of education and have developed games for educational purposes. However, one major problem of this kind of educational application is the construction and use of the game itself. The virtual reality user interface of such an application is extremely demanding and there are some important differences between learning software and computer games. An important piece of the enjoyment of games are the multimedia aspects, such as realistic graphics and sounds (Jones, 1997), however these could be seen as superfluous and perhaps even distracting in a learning environment. The budgets available to educational software, compared to some games companies also mean that it is not likely that many learning environments will have quite the same feeling of realism as games. Jones (1997) goes on to explain that good games seem to employ 'twitch', where a user must react quickly to circumstances to continue playing and 'strategy', which requires higher order thinking and problem solving skills. These different elements though are obviously meant to enhance the enjoyment of a game and most learning is concerned with continuing and completing the game rather than taking anything useful out from it. Learning from mistakes and past experiences can be very valuable, especially with regard to interaction in computer environments. However accepting new ideas and rules to complete a task is easier in games than in educational software because they are not constrained by content. Different elements, whether abstract or unreal, e.g. health restoring pills, can be added to a game to make it work, while in a learning environment new elements cannot be added at the expense of the content (Jones, 1997).

2.4.2.2 Examples of learning through gaming

Virvou et al (2002 and 2004) look at multi tutor games to help teach geography, biology, history, spelling and maths. The geography game (VR-ENGAGE) had been previously evaluated with respect to its educational effects on students and showed these were better than conventional learning software, though there was insufficient evidence to support an improvement in learning outcomes. The other four VEs require the student to go through each (in any order) to obtain an overall score that allows them to reach a land of knowledge. Students thought the worlds needed improving to let the game become even more adventurous and competitive to commercial game products. These multi tutor games were again shown to promote motivation in students to learn subjects that were unconnected and therefore help motivate the students to try harder in all learning. However there were many cases when the virtual environment drew the player's attention so much that s/he had missed the main point of the educational game (which is learning a specific subject). This was the case in situations when players had to get a hint on completing a task from an agent not in the immediate vicinity and had forgotten the hint by the time they had returned due to another distraction. It was also revealed that novice student-players made quite a lot of navigational effort. This means that on average they had wasted quite a lot of their time trying to find their way in the virtual reality worlds and thus they had been left less time for reading the theory and answering questions that would help them extend and consolidate their knowledge.

Champion (2003) discusses how users of a virtual heritage 'game' might ignore the environment in order to win the game (to finish tasks etc). Observation of the setting must be an essential part of the game. A time-based task (a typical component of games) means that people would be punished for contemplating their surrounds. So we need to reduce or replace the time constraint, by making time based goals only part of the experience, or the timing could be triggered by significant events.

Voth (2004) looks at gaming technology to help troops learn language and social skills with hints and feedback, allowing the user to practice skills in virtual scenarios they might soon encounter. It uses voice recognition software which can tell how well somebody is pronouncing a word. Users don't get too frustrated and can navigate quickly and easily just like playing a game.

2.5 Collaborative VEs

2.5.1 CVE Technology

Collaborative Virtual Environments (CVEs) are where more than one person interacts with the same environment and with each other. Communication takes place on a client-server model, where the environment is stored on a server, which communicates with the different user's machines (clients). These clients can be in the same room or building as each other, connected over a local intranet, or they could be on opposite sides of the world, connected over the Internet. There are many issues with CVEs being connected over the Internet in terms of performance, such as the lag between when one user's actions are seen by another user, problems with sound quality or a lag between a visible action and a connected sound or elements within the CVE appearing to do odd things due to incomplete (broken) data being transferred between users. The author though will concentrate on systems that can be run locally on an intranet, which while they may face similar issues to CVEs run over the Internet are less accentuated due to the closer connections between server and users.

Reynard and Eastgate (2001) give an indepth report into software tools used for developing CVEs including Massive, Dive, Interspace, CU-SeeMe VR and Freewalk which are custom built tools used openly in research of both technical elements and interface issues of CVEs including input devices, navigation and interaction, Head Mounted Displays (HMDs), user embodiement, communication, gaze and gesture awareness, field of view, collaborative learning, object interaction and behaviour, rendering of images and objects with realtime video and points of view.

2.5.2 Learning in CVEs

Collaborative learning has been shown to be consistently superior to traditional classroom lectures in both effectiveness and satisfaction (Smith et al, 1999). There are already many teaching strategies for people with AS which involve collaboration, using activity based learning where possible and encouraging cooperative games (GSSEU, 1998). This follows the constructivist learning principles discussed in 2.4.1, and when looking at learning in a social context, then this is especially true as it will involve verbal interaction, collective decision making, peer teaching and conflict resolution (Roussos et al, 1999).

For the potential of any CVE to be fully realised, an important factor to be taken into consideration is social presence. Slater et al (1996) broke this down to two contributing factors, personal and shared presence, which together were required for an effective collaborative decision making environment.

- Personal presence is related to the sense of being in a virtual space as the individuals state of mind and his actions in the environment.
- Shared presence is related with the perception of others being in same environment and the group behaviour.

These factors can also be relevant to learning social skills in SVEs and should be taken into consideration in those programs as well. Scenarios within SVEs contain interactions between the user and virtual characters controlled by the program, but these characters could be perceived to be controlled by an actual person by the user who will respond to them in the same way as if faced by a real person (Parsons et al (2004) found that the majority of participants with ASDs in their study imbued characters in VEs with 'people-like' interpersonal behaviour).

Riva (1999) states that the social context in which the VR experience occurs plays a crucial role. The context can be conceptual as well as physical as users perceive situations using cultural models and this context itself is unstable as the cultural models used are constantly modified by the users actions and choices. So in other words, we have to be careful when creating the VE to take into consideration a person with AS's perception (see also section 2.6.2) of what is occurring and how any learning effects at one level will affect their learning at the next.

2.5.3 CVEs for Special Needs Education

All of the applications presented, in the section above, facilitated interaction with the VE, including navigation through the environment and manipulation of objects within it. None of the work so far has examined the possibilities of Collaborative Virtual Environments (CVEs) in any sort of application for this user group. This section describes the framework for the only project that has been found to be proposing the use of this technology.

Almeida and Ramos (2000) describe a framework for the use of CVEs to promote the education and social interaction of people with Down's Syndrome. People with Down's Syndrome may exhibit traits of social avoidance in learning activities, they usually have good visual ability but have problems with language. The use of contextually situated networked environments is hoped to be able to facilitate four levels of interaction. These levels are:

1. Interaction with the system
2. Peer interaction
3. Curricular activities
4. Construction of situated knowledge

The CVE will also allow a virtual therapist to mediate communications and launch activities. The CVE has yet to be implemented and so practical information as to how to design the VE and feedback about the facilitation of peer interaction and the structure of collaborative activities is not available.

2.6 Use of VR for AS Education

2.6.1 Teaching Strategies

The Government of Saskatchewan, Special Education Unit (GSSEU), states that people with AS frequently lack understanding of social customs and may appear socially awkward, have difficulty with empathy, and misinterpret social cues. They are poor incidental social learners and need explicit instruction in social skills.

Students with AS may interrupt or talk over the speech of others, make irrelevant comments and have difficulty initiating and terminating conversations. Social communication problems can include standing too close, staring, abnormal body posture and failing to understand gestures and facial expressions. Their thinking tends to be rigid and they have difficulty in generalising things they have learnt into other contexts. However, they do have good memories and can learn and memorize rules about what kind of behaviour is appropriate (Dautenhahn et al, 2000), even if it is unnatural and they cannot comprehend why the rule exists. However they find it difficult to transfer those rules to the real world as they are not good at generalising and therefore cannot see why something applicable in one context can be applicable in another. The student with AS also finds it difficult to learn from their mistakes. Strategies listed by GSSEU (1998) and Atwood and Gray (2001) to help learning in the classroom include;

- Teaching the student how to interact through social stories, modelling, role-playing and other activity-based learning.
- Conflict resolution is managing disagreement with compromise and recognising the opinions of others, knowing not to respond with aggression or immature mechanisms.
- Appropriate opening comments, turn taking, interrupting and changing conversational topics are also taught as well as looking out for people taking advantage of them.
- Their strengths are capitalised on e.g. memory, and they are given positive praise whenever they have done something right or well.

2.6.2 Attributes of VEs for ASDs

Crosier (2000) gives five attributes of VEs that are beneficial for education purposes;

1. Visualisation and Manipulation of Invisible Phenomena - an ability to represent objects or concepts that cannot be seen in the real world.

2. Ability to Take on Different Perspectives - the technology's facility for taking on different viewpoints can help to increase understanding.

3. Exploration of Dangerous Situations - ability to visualise things which are inaccessible due to danger.

4. Reality and Altered Reality – creating environments without physical bounds or unnatural laws, e.g. walking through walls.

5. 3-D Representation of Abstract Concepts – can remove need for mental transformation of 2D information (text or drawings) inside the mind.

Studies that have been reported so far have demonstrated that children with autism are able to interact and respond to VEs. The attributes of VEs indicate that they should provide some educational benefit to some people with autism, e.g. allowing people to take on different perspectives or explore dangerous (or in this case uncomfortable) situations. The features of VR mean that the learning experience may be flexible; interaction can occur in real time and there are the added benefits of presence or a feeling of ' being there' . This feeling of being there can only be true if people with ASDs, who often interpret situations and language literally, unaware of underlying meaning, take an overly literal interpretation of a VE, thereby limiting its usefulness (Parsons et al, 2004). Parsons et al, (2004) carried out a study to see if people with ASDs understood VEs to be representational and thereby make a non-literal interpretation about the behaviour of people in the VE, e.g. would two avatars facing each other in close proximity be seen as being socially engaged with each other even if their mouths were not moving. It was found that the majority of participants did indeed interpret the VE in a non-literal way and imbued the avatars with 'people-like' interpersonal behaviour. It was also found that overall, people with ASDs were able to use VEs just as well as those without ASDs who were of similar intelligence.

People with autism or AS are characterised by a triad of impairments in imagination, communication and socialisation. These deficiencies in social skills, used to diagnose autism and AS, are described in more detail by Parsons and Mitchell (2001). Learning in VEs may overcome some of the difficulties experienced when trying to teach social skills to people with ASDs using traditional methods as they allow the realistic portrayal of real life social situations without the problems of interaction with real people. Moore et al (2000), when proposing a framework for research and development, makes a case for certain types of CAL systems to be built, including the use of Virtual Reality for simulated role playing activities for rigidity of thought and social skills learning.

If everyone using the system is in the same place, then why use a VR system at all? why not just use real rather than simulated roleplay? Strickland et al (1995) and Strickland (1997), state that VR systems are good for teaching people with autism as;

- Complexity of scene can be controlled.
- Successive and controlled adjustment of an environment is possible with the aim of generalising activities at different but similar settings.
- A learning VE can be realistic, easily comprehensible and at the same time less hazardous and more forgiving than a real environment, when a mistake is made by the user. Thus, a VE provides us with a safe and controlled setting for developing skills for everyday life activities.
- Thought patterns of people with autism are mainly visual and auditory, the stimuli which VEs focus on.
- Autistic people like to go at their own pace (speed of presentation important).

Also due to the small area of focus of a computer screen, external events can be more easily ignored as people with ASDs attention is usually fixed as if viewed through a tunnel, and in terms of accessibility, many people with autism are comfortable using standard computer hardware (National Autistic Society, 2001). CVEs can be tailored to individual needs/abilities and offer non face-to-face communication with control over verbal and non verbal features offering a stable environment, while maintaining group cohesion (Parsons et al, 2000; Smith et al, 1999). The fact that there is no face-to-face collaboration is important, as while it presents problems to the wider community in terms of how people view their peers, the ability to allow people to publicly take intellectual risks (as their identity is hidden behind an avatar) in front of their peers will be of great benefit to people with autism, who have difficulty in interacting socially (Smith et al, 1999).

Strickland et al (1995) talk about the benefits of immersive VR as it can isolate autistic individuals from their surroundings in order to help them focus a specific situation and a limited set of experiments showed an encouraging adaptation of a small number of subjects to an immersive VE. Shin (2003) also suggests that in general, desktop VEs do not support immersion or the full presence as fully immersive VR. Shin does however report that learners understand the learning subjects well in desktop VR and Robertson et al, (1993) found that desktop VEs can still give a feeling of subjective immersion, especially for visual search tasks. As there are possible ethical and health issues in using headsets (see section 2.6.3) and with Strickland (1997) finding many people with autism disliked wearing them, then desktop VEs can provide an effective solution. A possible way of making desktop VEs more immersive is to have the environments displayed in stereo with the user wearing special glasses to allow them to see this effect of added depth perception. Again though there may be problems in the user wanting to wear the glasses and Trindade et al (2002) found that stereoscopic visualisation does not seem to contribute much to conceptual understanding. In spite of some sense of immersion provided by the stereoscopic view, results for screen and stereoscopic glasses were almost identical.

Poland et al (2003) when looking at mainstream education did report a diminished sense of realism due to the flat screen medium used. They also go on to say that realism was important in helping students to maintain interest and accept the scenario and this was directly related to the media used to deliver the scenario. Early evaluations revealed that some students have very high expectations of the computer interface, and if the media used did not 'measure up' to their expectations, they lost interest.

2.6.3 Negative factors for VR in Education

Crosier (2000) found that not all the evidence for VR in education is positive. There are some criticisms and potentially negative factors that must be considered. For example, the health and safety aspects of using VR, especially immersive VR using HMDs. Many studies have been carried out to look at the side effects of using VR on an adult population and some have found that nausea, headaches and dizziness can occur as a result of HMD use (Cobb et al., 1999; Nichols et al., 1997).

Studies using immersive VR with school children have also found worrying health and safety effects. Bricken and Byrne (1992) found that students reported feeling dizzy and nauseous after using the head-mounted display. Dede et al (1996) measured simulator sickness for both an immersive VE and a 2D computer. Results showed participants to be more susceptible to simulator sickness following use of the immersive VE. In another study, Osberg et al. (1997) found that about a quarter of the participants experienced nausea and dizziness following use of immersive VR. Only five percent of users reported sickness and dizziness in a study by Roussos et al. (1999) in which stereo glasses were used instead of a head-mounted display.

Winslow (1996) fears that prolonged exposure to multimedia learning environments may compromise verbal skills and also raises concerns over whether the subtle differences between the VE and 'the real thing' will become indistinct and cause confusion for learners. He also points out how important it is to choose appropriate application areas for VR.

2.6.4 Interface Issues

People with AS should practice role playing in the context of a social story to aid the acquisition of cognitive mechanisms for friendship skills (Atwood and Gray, 2001). Taking on different roles will enable the student to more quickly experience the different possibilities and consequences of the actions they take. In a CVE, a large part of the learning will be the communication between users. This communication could take the form of text being typed at each terminal and being displayed under each user's avatar or it could be verbal, through talking and listening to each other through a headphone set. If using a headphone set then the earphones should be stereo with one earphone for listening to what other people are saying while the other has sounds occurring in the environment (Smith et al, 1999). This would overcome difficulties of the user's speech and important environment sound elements interfering with each other. It should be noted however that when using sounds in environments for people with autism that 'extra' sounds to enhance the environment should be avoided as this will distract and confuse the user (Charitos et al, 2000). The environments should also encourage constructive discussion between the users to talk about ideas and not focus on talking to each other solely for the purpose of completing a task (Johnson et al, 1999). With regards to an SVE, this could also be accomplished by using it in a group situation where users can be in joint control of the decision making process (even if only one person is actually physically in control) and discuss ideas between them while collectively watching the interaction to the VE on a large screen.

Eriksson and Gardenfors (2004) when looking at 3D computer games for visually impaired children showed that it was possible to create fun games for them with the appropriate interface. These games use distinctive bold shapes to help visualise elements whilst also providing non-speech based auditory feedback. Sound was best used for action based sequences whilst shape visualisations were best used for puzzles. They noted however the difficulty in using non-speech auditory commands as in western culture there is a lack of conventions on which they can be based.

2.6.5 Teacher Role

VEs can be quite complex in terms of trying to predict all the possible behaviours and responses that will need to be programmed. So instead, only the main factors governing the learning are included and anything that is more 'open ended' can be discussed with the help of the teacher who can guide the students and get them to talk about what they are doing (Edelson et al, 1996). The teacher therefore becomes a 'privileged' member of the knowledge building group, one who creates an intellectually stimulating climate, models learning and problem solving activities, asks provoking questions and provides support through coaching and scaffolding. Poland et al (2003) also report that students felt there was still a need for a teacher when using learning VEs and that some gained confidence from group work. The VE therefore must be built as a tool, which can fit into existing teaching strategies as well as offering something new (De Corte, 1993). This strategy is also advocated by Bowmen et al (1999), who state that it is dangerous to solely rely on experiences for learning as incorrect mental models can arise logically and that VEs can provide an important first step in understanding, but other knowledge and teaching are necessary for complete comprehension.

2.6.6 Communication

Another form of communication in the VE is through the 'body language' of the avatars, whether they are other users or computer characters. Previously, strengths of collaborative systems have been verbal or text based communication, while action based communication performed by the user' s avatar is limited. This is not so bad when using the environment for people with AS, who have difficulty in understanding expression of emotions, motives, beliefs and intentions and a failure to understand gestures and facial expressions (Charitos et al, 2000; GSSEU, 1998). Cuddihy and Walters, (2000) state that users should be aware of other users and their work, allow a user to see what others are focussing on and convey a sense of users current activity, which increases social presence. While these features are important in helping the users communicate with each other, many of them are the issues which we are trying to teach people with AS in the first place. Therefore the program will have to be able to communicate to users in a way which conveys meaning relevantly and at the same time gradually present action based communication to the user in a controlled manner which aids the user in learning these features. A possible method of achieving this is to present images, which convey meaning and are understood by the student with AS. Symbol cards have been very useful in teaching people with autism and the TEACCH program has incorporated such visual representations (Charitos et al, 2000). Images are metaphors for concepts and they provide an alternate reality, which is simultaneously concrete in structure and analogic in representation (Riva, 1999). So the user can be provided with visual queues to understand the other users behaviour and gradually replace these metaphors with hopefully more realistic human behaviours in the avatars in order to transfer the meaning.

Another problem in communicating meaning to users or seeing what actions they are taking is will the user be aware of any feedback given within the VE. In a CVE, will one person actually see quickly enough what the other users are doing and in SVEs will they see the reactions of avatars or other visual cues on screen. People can spend too long orientating their avatars and miss what is happening. So while freedom of movement to explore is important, it can take away from collaborative tasks, social activities and therefore learning (Cuddihy and Walters, 2000). This means that under certain conditions it would be better if the program could automatically orientate users so that they are automatically facing the right way to receive relevant information.

As well as being able to facilitate good communication between users and the learning task, there are a number of other factors that VEs should conform to if they are to be seen as usable. The system has to be able to answer the following questions positively. Can users accomplish the tasks they accept? Can they acquire the necessary information? Do they have the necessary control? Can they correctly sequence their subtasks? (Riva, 1999) The program should allow users to have some idea about what the VR system expects and can handle and conversely the program needs data on the person's goals and behaviours. In terms of learning environments the system should help learners treat knowledge as an object to be discussed, yield perceptible progress and help learners see how they contribute to a group's knowledge (Riva, 1999).

2.6.7 Appropriate Interface

Cuddihy and Walters (2000) proposed that appropriate interfaces to VEs should be dynamically constructed depending on what actions were available to the user at that time as a way of solving the problems mentioned above. Previously, many interfaces consisted of action panels, which present a palette of graphical buttons for which the avatar can perform. This action panel metaphor is context independent so the user would perform the action they chose no matter their current situation, where only the consequences of the user's actions would be dependent on their situation. However this can be limited and does not help the user know what actions are appropriate at any given time and to what objects they can effect. So instead, embodied activity would be presented dynamically to the user at an object level as opposed to the scene level. For instance if a user wants to wave at someone the icon to wave will only appear if there is someone else in the vicinity. When pressed a list of people that can be waved to is shown. When the user selects a person their avatar will automatically rotate to face the user they are waving to, thus overcoming the navigation problems mentioned earlier. An example of a user interacting with an object would be if they pressed 'pickup' and then a list of objects *near* to the user which *can* be picked up is shown, or conversely the object is clicked on and a list of possible actions that can be performed on it appears. This type of interface then helps the user to know what they are capable of at any time thus reducing confusion and the number of errors made.

However sometimes errors need to be made in VEs in order to learn as this stimulates creativity and exploration of alternative approaches (Kulathuramaiyer and Siong, 2000). Therefore again, a balance has to be made between allowing the user to make errors and clearly showing what options are available at any given time. In the AS

Café scenario, the user is free to move where they like, however as soon as they are close to a table that has an available seat, the user will be automatically rotated to face the table and then asked what they want to do. They can then choose to continue trying to sit at that table or they can move away to somewhere else in the cafe. As the user has to be close enough to a table group to interact with it, they will be told to move closer they try to click on objects within the table group when too far away.

Virvou et al (2004) found that while playing a game, a player must become familiar with its user interface. This is very important because the level of understanding of the user interface of a game is an essential part of the story of the game and the user's experience of the adventure. Playing will become easier and more interesting if players are aware of the components, functions and tools that are accessible to them. In a learning VE, the interface therefore should be as intuitive as possible, though it should be expected that users may take time to become totally familiar with it.

2.7 Scaffolding Educational Software

2.7.1 Need For Structure

Structure is vital in teaching students with autism, as consistency, predictability, stability and simplicity are required. Activities are usually structured with organized materials, clear instructions and a hierarchical system of prompts, and enhanced by routines and visual aids that are not language orientated (Autism Society of America, 2001). Eriksson et al (1997) note that in order to learn, students with disabilities need an active tutor, as they are not capable of the self-directed learning required in the constructivist theory.

Scaffolding of learning takes two main forms, to guide the user in their learning and to take into account the different levels of abilities. Most scaffolding is programmed into the software where the user's actions and sometimes their previous action s will determine how the interaction unfolds. Dean et al (2000) show that a 'hint' functionality provides explicit instructions for task at hand and becomes increasingly specific as the student continues to have difficulty, while the provided information has to be sufficient to make VE accessible to inexperienced users without sacrificing the challenge for more advanced users. Whitelock (1999) used a learning task, which was tightly structured, especially on the feedback, to scaffold learning, where after three wrong attempts at a task, a 'Show Me' button appeared. She found that the students appreciated the guidance provided and that they achieved higher cognitive change scores using this software compared to others.

2.7.2 Intelligent Agents

Intelligent agents are programs which monitor the students use of the computer and intervenes at appropriate times depending on their task and level of ability. These agents can either be anonymous programs running in the background, communicating to the user through text or sound or they could manifest themselves as a virtual character that appears on screen to help. Eriksson et al (1997) suggest that a teacher like guidance should complement the learner's activity and the level and quality of guidance will depend on the learner. Intelligent agents seek to scaffold the trainee's introduction to and use of the 3D environment. Chuang (2003) identified four characteristics as being necessary for intelligent agents:

- **Deductive Character –** The agent should introduce goals and learning objectives, and assist the trainee in mastering the control system.

- **Monitoring Character –** The agent should observe the student's progress, giving additional instruction, support and demonstration where the student is having difficulty or gets into a hazardous situation.

- **Motivational Character –** Successful achievement of goals should be rewarded with positive feedback, however, since some safety issues may have arisen from the student's behaviour despite a successful result, the agent may need to direct the student to repeat a task until no safety issues arise.

- **Solution-address Character –** The agent should provide incidental advice and guidance on request or in response to the breaking of a rule.

These four characteristics were incorporated into a travel training VE for adults with learning disabilities (described in Shopland et al, 2004) with two differing approaches. One approach used an active, animated 3D figure, and the other a static 2D representation of a tutor. It is not stated if one was preferred to the other overall and it may just be a case of individual preference as to which one was used. Evaluation was conducted by observation, recording the duration and frequency of trainer interventions and user errors with and without a virtual tutor. Trainer assistance, task completion and user satisfaction were all noted to be enhanced in the environments augmented by an intelligent agent. A set of design guidelines for the implementation of visible intelligent agents for people with learning disabilities were developed from these studies (Chuang 2003):

- Use simple and short language
- Consistent layout or controls for visible Agent
- Use plain background
- Use step by step instructions to guide users
- Provide positive feedback
- The speech of the text should be recorded by native speakers, or use text-to-speech techniques
- Provide dismissible functions while they are not essential
- Limit lengths of animations
- Agent behaviour should not be too complex
- Avoid use of voice input
- Minimize distraction from learning, for example give reminders without requiring learner's full attention.

These guidelines build upon previous work by Brown et al (2001, 2002) and Standen et al (2002).

It can be difficult to program agents effectively however, especially in the context of special needs learning and the intelligent agent framework may be more suitable to non-disabled students as amongst cognitive impaired children, the computer cannot be applied for independent work, because the educator should be there all the time (Eriksson et al, 1997; Kiswardsy, 1996). Agents and scaffolding in general can help though as found by Chuang (2003) and while agents should be designed for independent work, they should also incorporate the role of the teacher.

2.7.3 Teacher Role

Teachers provide a pivotal role in the use of the learning software, as they need to be on hand to help in certain situations to ensure learning objectives are met (Kerr, 2002). Thus, it is not *what* equipment is used, but *how* it is used in the classroom that will make the difference (Lincoln and Strommen, 1992). How VR is to be used in schools needs to be considered early in the design process and it should form part of the instruction, not be the whole lesson (Crosier et al, 2000). Dean et al (2000) agree and are convinced that properly implemented VEs can serve as valuable supplemental teaching and learning resources to augment and reinforce traditional methods. Aiken and Aditya (1997) bring to attention that many teachers are reluctant to utilize technology, fearing that it could distance them from the student, but Lincoln and Strommen (1992) and Taylor (1996) argue that as long as appropriate points for integrating technology are found and the teachers have a view of how to use it beforehand, then the teacher can become a member of a team rather than the focus of the classroom, they will be seen as a colleague, not as a superior, who can be turned to for assistance when required. To achieve this though they argue that teachers must be comfortable with and appreciative of the features of the software and hardware in use and be provided with the time and support to explore technology on their own. This requires an integrative IT policy within the school, supported by head teachers, who can encourage staff by providing workshops and training and help improve staff awareness of the technology, showing that it is just another resource to be utilised rather than an end in itself.

2.7.4 Input Devices

Standen et al (2004) say that virtual environments have a role to play in facilitating the acquisition of living skills in people with intellectual disabilities, improving their cognitive skills and providing them with entertainment. However, the currently recommended devices to allow navigation in and interaction with the environments are difficult to use. Results suggest that for navigation, the joystick is better than the keyboard but that for interaction the mouse is better than using the fire button on the joystick. Preventing slippage of the joystick base would make its use much easier and it is suggested that separate devices are retained for navigation and interaction.

2.7.5 Viewpoints and Visual Cues

Shopland et al (2004) looked at a virtual training package to teach people to cross the road. In it they compared how users felt using an avatar from a 1st and 3rd person perspective. It was apparent that for the user population they used, the fixed 3rd person perspective was preferred, and so was made the default view, though of course the option to change viewpoint was made available. A scaffolding feature of this VE was to have a traffic density of zero, which would allow the user to get used to navigating their avatar when crossing the road without fear of making a mistake due to a lack of control of the input device.

Shopland et al (2004) also looked into triggering events by walking the avatar into items, but found the approach of using a hand cursor to represent people activating something by hand to be more useful, being more comprehensible to the learners and a more positive representation of the real world action. While this is desirable, there may be occasions where the element to be activated within the VE is very small or the user has poor motor control (Brown et al, 1997b) and so alternative strategies for triggering events might be appropriate. Shopland also looked at giving visual cues to indicate when a user was in an appropriate position, but had reservations about this due there being no such cues in the real world. Whilst this is true, it is one of the benefits of VR to visualize things not seen in the real world to aid learning. A possible way to satisfy this concern is to only have the visual cue in the easier levels of a learning VE along with other scaffolding to allow the user to learn how to initially use and behave within the VE. Then as they improve, this scaffolding can be removed so that hopefully the user is comfortable using the VE without any help and therefore at a stage where they can try their skills in the real world.

2.8 Appropriate Use of SVEs and CVEs

Both single user and collaborative environments have their attributes as learning tools as discussed in sections 2.5.3 and 2.6.2. So when should one be used instead of the other and what measures need to be taken to make sure the full potential of each is realised in a learning context.

Neale et al (1999) state that in learning environments, the complexity of tasks should be increased gradually to the levels experienced in the real world as a user becomes more proficient. So for each overall learning objective, we have to break down the tasks to a very basic, controlled level and then introduce more and more stimuli and choice as the users ability increases. So for example, in the AS Interactive project, while an aim is to have users collaborating in a social learning context, they should first use an environment that gets them used to the metaphors of sitting down, standing up, asking questions etc, and then exposing them to incremental learning objectives and stimuli that will eventually combine to form a fully collaborative social environment.

Whilst CVEs are more realistic in that they allow for social interaction between real people, their unstructured nature (the program will not know what the users are saying to each other) may be problematic. The NICE (Narrative, Immersive, Constructionist/Collaborative Environments) project at the University of Illinois, an exploratory learning environment for children between the ages of 6 and 10, was an explicit attempt to blend several learning and pedagogical themes within a single application (Johnson et al, 1999). The NICE garden was originally designed as a CVE for young children to learn about the effects of sunlight and rainfall on plants, the `spontaneous' growth of weeds, the ability to recycle dead vegetation, and similar simple biological concepts that are a part of the life cycle of a garden. NICE supported real-time distributed collaboration with voice communication enabled by a real-time audio connection. The CVE used here was unstructured and undirected which brought problems, so in the follow up project, The Round Earth Project, structure and learning goals were more effectively integrated from the beginning, though the effectiveness of learning was not clearly demonstrated (Johnson et al, 1999). CVEs therefore may not be suitable to have significant structure incorporated within them, and students who require a lot of structure will need to initially use SVEs until they reach a level of ability where they can use a mainly unstructured CVE.

2.9 Discussion of Literature Review

The review of literature has highlighted that while the flexibility and potential of VEs lends itself to the constructivist theory of learning, there still has to be a degree of structure inbuilt into the program to guide the user along an appropriate learning path. This is especially true when designing VEs for people with autism who otherwise would not be able to use a learning program, as so much of their thinking and daily lives are based around structure and routine. The structure in learning programs can resemble the form that some computer games take. The difference though is that games are based around achieving the end result whereas in learning software the route taken to achieving that goal can be more important. This is also true of CVEs which offer almost infinite learning possibilities, but only if the structure is effective otherwise the opposite can easily be the case with very limited to no learning taking place. Collaborative learning is seen as being extremely effective and while CVEs obviously accommodate this attribute, some form of collaborative learning can also take place with an SVE, with more than one user making decisions on how to complete a task or with perhaps one user controlling navigation and another interaction.

This chapter has shown the problems faced by people with autism and AS in particular regarding social skills. Their behaviour can often be seen to be awkward, disengaged rude or even anti-social and this would mean significant problems in finding and holding on to a job. People with AS have great difficulty in generalising and learning from their mistakes, which makes it problematic to think of teaching strategies to help them learn appropriate social skills. Strategies that *are* seen as effective though are social stories and roleplay and these can of course be capitalised on in a VE. Strickland has shown why VR systems are good for teaching people with autism and revolves around the fact that VEs can represent a situation in the real world fairly realistically but with an element of control in the stimuli received by the user depending on their abilities and sensitivities, while of course allowing the user to make mistakes freely with no real consequence.

Communication is a key factor in learning and of course in social skills, so it is important that there is good communication whether it is between users or between a user and the VE. Communication between the user and the system is through the interface and must use language and symbols that are meaningful while at the same time be uncluttered. It is recommended that the interface is dynamic so that the user has an idea of what is possible at a given instance and reduce the capability of making errors. The user may need to make errors though in order to learn, so the system has to offer the capability for the user to make the same errors that they would in real life as opposed to errors due to bad interface design. The system also has to take into account the type of communication or behaviour that the user might expect to show and be able to deal with it accordingly. Therefore the way in which the user navigates around the VE and interacts with objects has to be taken into consideration, any feedback given to the user, either through the interface or objects (including virtual characters) in the VE has to clearly be meaningful and understood by the user. The user must also be aware of this feedback, so having an interface which could give instructions in both visual and audible form with the user automatically orientated to see important visual feedback in the VE itself would benefit the user greatly.

Communication between users in a CVE or in a group can be problematic for people with autism and so the teacher plays a crucial role in facilitating this communication either as a character themselves in a social story or by encouraging discussion about events just experienced through the VE. The system therefore has also got to take into consideration this role by the teacher, as they become in part a user of the system. This highlights that the VEs can not just be a stand alone system thought of in isolation, but an integral part of the teaching process and so how the system is used in practice needs to be considered from the beginning.

Scaffolding a VE to promote learning therefore has to include structure both within and outwith the system, with both being dependent on each other. The structure within the system has to take into account varying levels of ability and be able to guide the user down appropriate learning paths. The level of scaffolding is seen as being at its optimum in the beginner levels of an SVE, with it slowly being dismantled as ability and learning scenario complexity increases towards where a CVE is required and beyond. The point at which a particular system is most suitable will be dependent on the individual application and will only become clear as development progresses. Table 2-1 summarises the guidelines reviewed in the literature for the use of VEs by people with AS.

System Element	Guidelines	*Chapter Section*
Hardware & Input Devices	Use Desktop System Joystick and mouse ok for general use	2.2.3; 2.3 2.7.4
Environment	Consider how system is used in practice Consider role of teacher	2.7.3 2.7.3
Interface	Use language and symbols that are meaningful Use both text and audio Be consistent Avoid voice input Use plain backgrounds Use dynamic interface	2.6.6 2.7.2 2.7.2 2.7.2 2.7.2 2.6.7
Interaction	Allow ease of interaction with small objects or use alternate strategies, e.g. icons on interface	2.7.5
Visual Aids	Automatic viewpoints, rotations and movements when appropriate Visual cues, though not too many	2.6.6 2.6.6
Intelligent Agents (scaffolding directly related to learning)	Provide positive feedback when something done right Avoid distraction from learning Use step by step instructions to guide users Allow errors to be made due to decision making, help user recover from errors Take into account level of ability	2.6.6; 2.6.1; 2.7.2 2.4.2.2; 2.7.2 2.7.2 2.6.7 2.7
Sound	Avoid extra or unnecessary sounds	2.6.4
Layout	Make environment as realistic as possible Have space to easily move around objects	2.2.2.1 2.9

Table 2-1: Literature Review Guidelines

2.10 Summary

This chapter has described the issues relating to the learning characteristics of VEs and how they can be used to aid teaching social skills to people with AS. How these systems can be structured to take into account the strengths and weaknesses of people with AS has been discussed in a general sense, with a number of specific factors governing the scaffolding of VEs looked at as possible options for design implementation. The above issues have been discussed in terms of SVEs and CVEs both separately and together as many points are relevant to both.

Chapter 3. Methodology of VE Design and Development

3.1 Introduction

User involvement is central to the development process used by the author and VIRART. Neale (2001, p45.) reported that the difficult task is not to decide whether or not to include users in the design and development process itself, but how to do it: "*However, involving the user in the design process is not straightforward, as there are many different ways in which they may influence technology design. Technology developers need to consider how they will involve the users in the design, when in the development cycle this will be, and what aspects of the design they will influence*."

This chapter will look at the design ethos of VIRART and how this shaped the authors previous experience of developing VEs for special needs education and how methods employed in this process evolved to the present where a toolbox of methods are used to help develop VEs for new user populations. A description of these different methods will be given and why they are relevant to the research in this thesis. An overview of the entire AS Interactive project methodology will then be described before looking at the author's specific section of this research and the methods utilized.

3.2 VE Design and Development

3.2.1 Platform Choice

The SVEs developed for the research in this thesis were made using Superscape VRT (Virtual Reality Toolkit), version 5.6, which the author has many years experience of using to build special needs educational applications. At the start of the project Superscape had stopped making its VRT software for a couple of years and did not support it any more, but there were few alternative VR toolkits which offered the versatility and the features required by this project which could be utilised in the given time, so it was decided to use Superscape initially while looking into other platforms for the possibility of transferring it later if required for commercial distribution. Other toolkits thought to offer similar capabilities were Virtools (www.virtools.com) and WorldUp (sense8.sierraweb.net). The main difference to the programmer is how the information is viewed and structured. WorldUp's object' s properties and the interaction between them are listed on a series of ' graphs'*scene*, *behaviour*, *type* and *models* which are contained in a ' workview' window is adjacent to the development window which shows the environment being made (see Figure 3-1). The workview graphs are a hierarchical list showing the order in which actions are taken, e.g. the order in which objects are rendered or lit or the order of events when objects are interacted with (see Figure 3-2). Another fundamental difference to Superscape is that 3D models in WorldUp are usually (with the exception of basic geometrical shapes) created in a modelling package such as Lightwave or 3D Studio and then imported into the VE toolkit. The author had used WorldUp briefly and while the work of Davies et al (2002) and Wallergard et al (2002) shows this platform can be used for people with special needs (in their case, people with brain injuries), time constraints on the project meant there was insufficient time to learn how to use the tool effectively and the package did not offer anything (apart from that it was still supported by Sense8 and could therefore be kept up to date with the latest technology) that would be beneficial to the project.

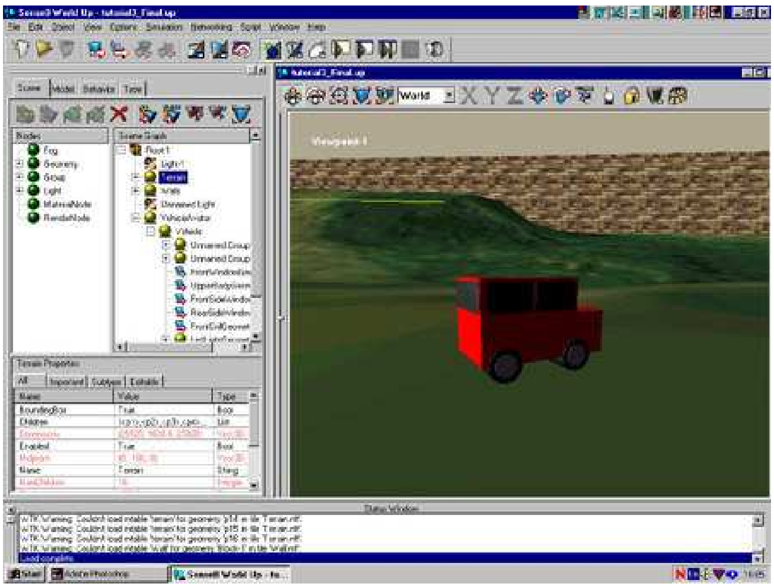


Figure 3-1: WorldUp™ toolkit developer interface

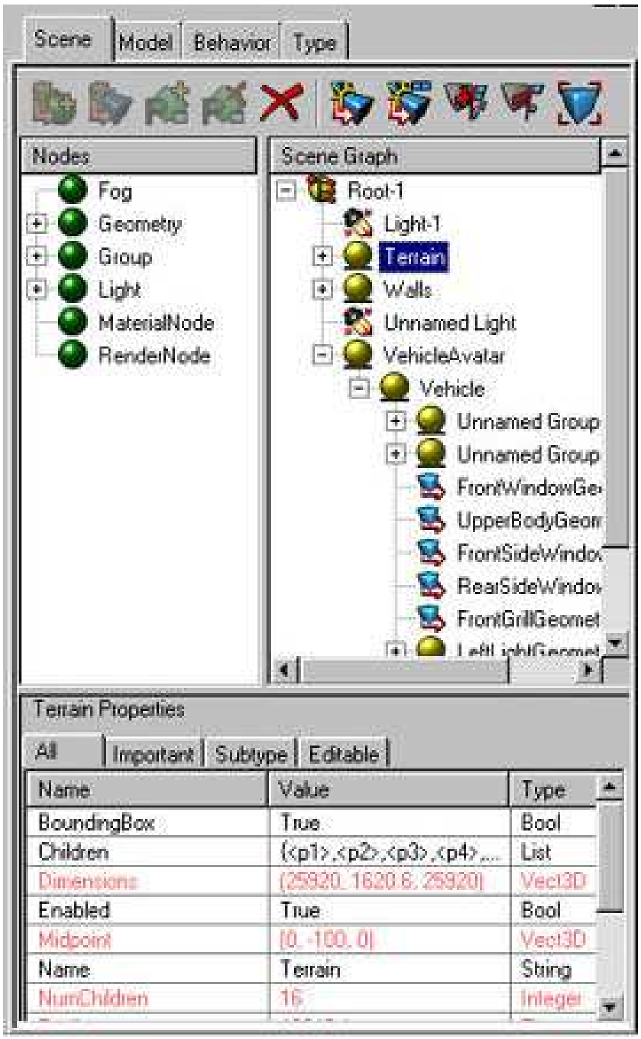


Figure 3-2: Hierarchal structure of WorldUp elements

Virtools DEV (www.virtools.com) is similar to WorldUp in that it requires models to be developed with external software and then imported into the VE developer kit where interactions are programmed in similar hierarchal structure as WorldUp. Virtools' user interface (see Figure 3-3) consists primarily of 3 main areas, Real-time 3D layout, content manager and building block library. The building blocks are predefined behaviours which can be drag and dropped onto 3D and 2D entities, while the content manager brings together the interactive and behavioural elements selected by the developer to create the real-time experience. A schematic view similar to a flow diagram can be viewed to help see more clearly this interactive content. The layout window manages the user's view into the virtual world with 3D objects, camera viewpoints, textures and lighting effects used. Various other sub editors are available which allow the developer to write their own program scripts (behaviours) and manage the content in different ways, e.g. manage attributes of single objects or see a hierarchical list of all objects, debug parameters and perform actions (predefined tasks) on all elements of the virtual world. The Virtools toolkit did not exist at the start of the AS project, though came into being as a beta product during the project. It was refined during the period of the project while other members of the VIRART team not working on the AS project familiarised themselves with it. An in-depth review of its capabilities with regard special needs education has not been carried out, but Virtools would be a strong candidate for use for future projects.

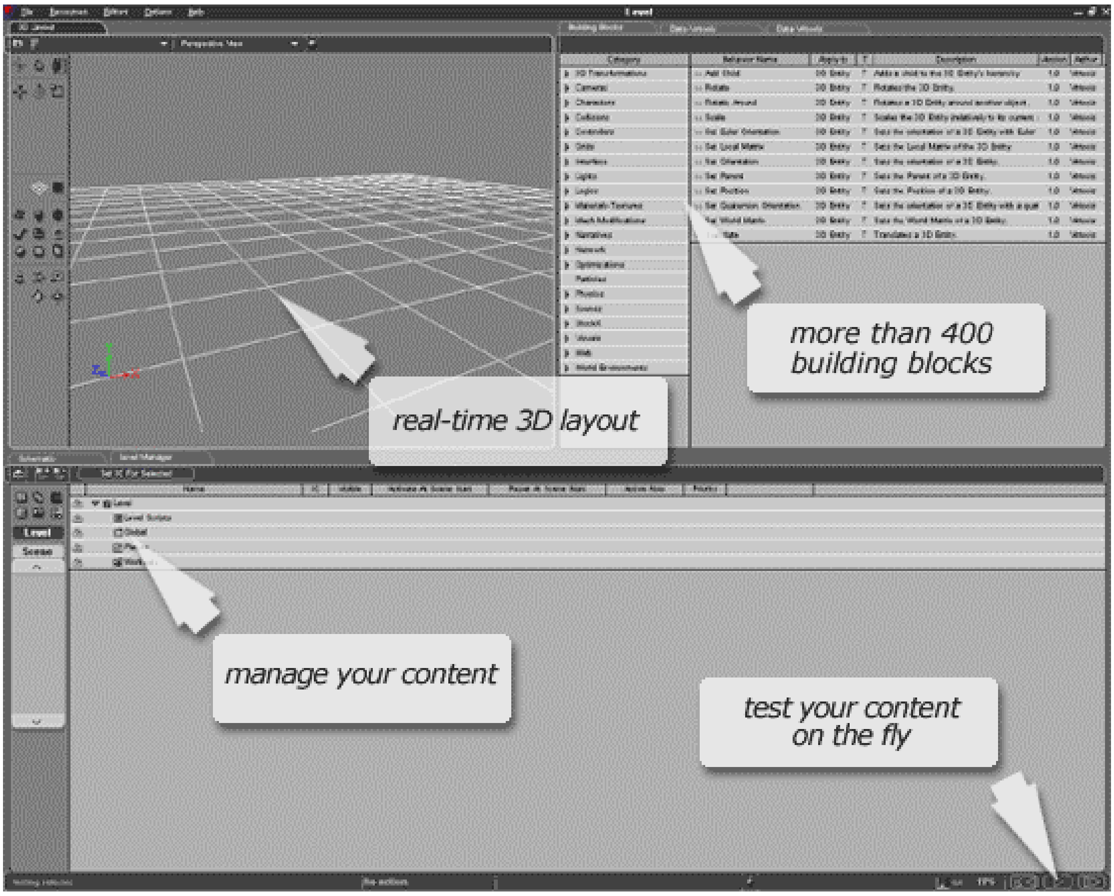


Figure 3-3: Virtools User Interface (www.virtools.com)

Other VE platforms exist which are not toolkits as such but program engines that are capable of producing 3D, interactive environments. These require more programming which means they have the benefit of greater control in programming exactly what is required, but with the downside of taking longer to program and being less robust (more likely to fail). Such platforms are discussed by Reynard and Eastgate (2001).

While this thesis discusses VEs developed using Superscape VRT, it should be noted that most if not all the issues discussed are relevant regardless of which platform is used, as they all share similar features.

3.2.2 System Overview

Superscape VRT has a number of editors inbuilt into the program to allow the creation of VEs. More information can be found in the Superscape (1998). These editors are summarised as follows;

Shape Editor – to create Shapes, the basic building blocks of Objects placed in the VE

World Editor – central hub of VRT, where everything from the other editors (bar the layout) are brought together to create the VE.

Visualiser – program which allows user to interact with VE (rather than edit the VE).

Layout Editor – creates the interface to the VE, e.g. 2D buttons, icons, graphics and 'windows' onto the VE, i.e. the users view of the virtual world.

Resource Editor – creates pop up dialogue boxes to give information to the user as well as allow the user to enter data or make selections from a series of menu choices.

Texture Editor – imports graphic files such as 'jpg', 'gif', 'bmp' etc which can then be edited and placed on the facets of objects.

Sound Editor – imports 'wav' files and allows changes to pitch, volume and playback speed of sounds used in VE.

VRT virtual worlds are 3D spatial environments, comprising groups of objects which consist, at the root level, of groups of shapes. These shapes and objects are contained within a bounding cuboid, which determines its collision detection. Figure 3-4 shows the tree like structure of how shapes are grouped to form objects by giving the example of a car broken down into its constituent parts. Figure 3-5 shows the bounding cubes of the various body shapes such as torso, head, arms and legs contained together in groups to form a virtual person.

Object structures

VRT uses a tree-like structure to enable efficient object sorting. For example, a car might be constructed as different groups of objects as shown below. There is a Group object 'Car' which contains the child objects 'Body', 'Chassis', 'Wheel 1', 'Wheel 2', 'Wheel 3', and 'Wheel 4'. Each of these objects is a sibling of each other, and each has its own children. If VRT decides that it does not need to draw Wheel 1, it can discard the Hub, Tire and Bolts from the calculation immediately.

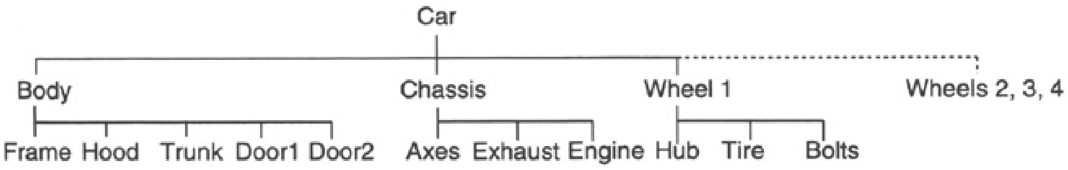


Figure 3-4: VRT Object Structures (Superscape, 1998)

Each object has a series of properties such as colour, size, position, rotation, dynamics, etc. that can be viewed by selecting either the object in the environment or from a list and then selecting properties from a menu option or an icon. The interaction in the VE between the user and virtual objects is controlled by Superscape's Command Language (SCL) programming code and this can be one large piece of code stored on one object or it can be a number of pieces of code stored on separate objects which can communicate with each other. The benefit of the latter option is that code on each object is usually relevant to it and so makes it easier for the programmer to structure the code and to debug it. The disadvantage is that sometimes a piece of code might be stored on an arbitrary object that makes it difficult to find, and the dispersion of code makes it difficult for anyone else examining the code to determine its logic. Figure 3-6 shows the SCL code attached to the head object of the virtual person. This code triggers the blinking and smiling animations of the two sides of the face (leftface and rightface) which make up the head object at random intervals to mimic the behaviour of a real person. In this case it is reasonable to expect to find the code relating to the eyes and mouth on the head object.

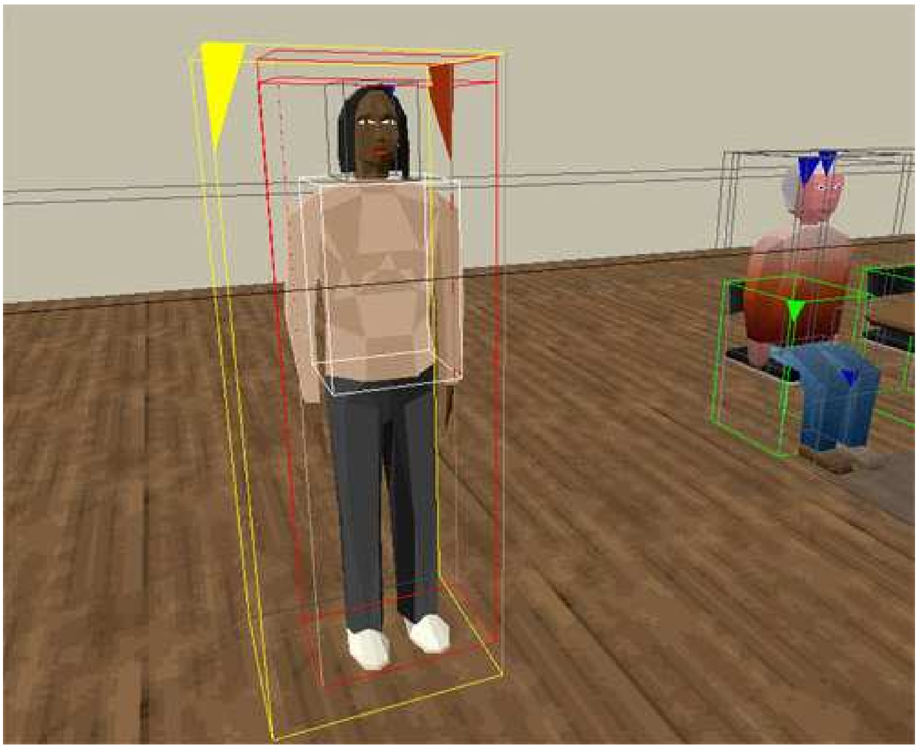
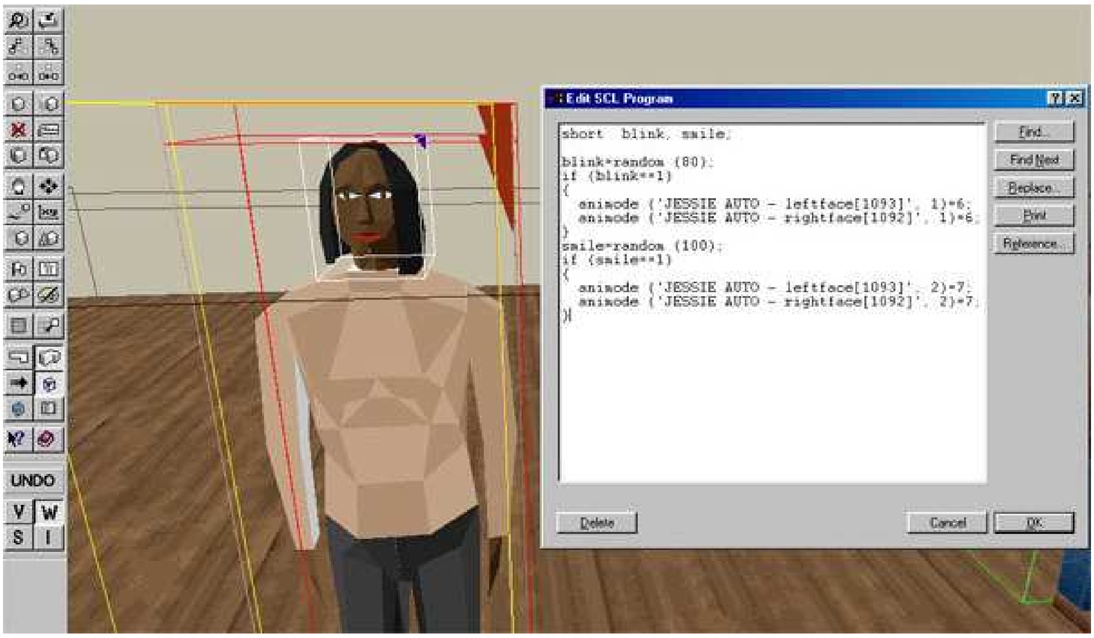


Figure 3-5 Bounding cubes of grouped objects in Superscape.




```
short  blink, smile;

blink=random (80);
if (blink==1)
{
animode ('JESSIE AUTO - leftface[1093]', 1)=6;
animode ('JESSIE AUTO - rightface[1092]', 1)=6;
}
smile=random (100);
if (smile==1)
{
animode ('JESSIE AUTO - leftface[1093]', 2)=7;
animode ('JESSIE AUTO - rightface[1092]', 2)=7;
}
```

Figure 3-6 SCL code of selected head object.

3.2.3 Shapes & Objects

In VRT, objects in the virtual environment are made from shapes, which are generated in the Shape Editor. The Shape Editor is a basic kind of Computer Aided Design (CAD) package where points are created in 3D space and then facets (single plane areas, e.g. squares, rectangles, circles that form the face of an object) are created between them (See Figure 3-7).

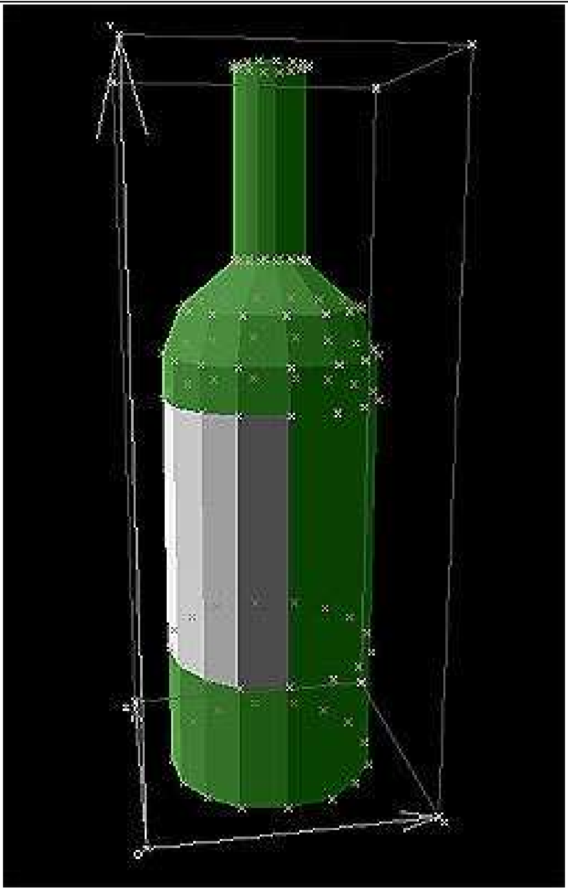


Figure 3-7: Bottle shape generated in VRT Shape Editor

Shapes can be used again and again within the environment and objects can be imported from other VRT worlds or object libraries. Objects in the environment can be grouped together as siblings or as parents and children, where the parent' s attributes affect its children. Objects can be rotated within the environment, although too many may affect the rendering of the environment and so should be kept to a minimum (Superscape does not give a specific limit as it can depend on the shape of the objects themselves). The position, size and rotation of an object can either be programmed in directly, the object manipulated on screen by the mouse, or by using a toolbar. When building objects from shapes, they should fit flush to each other due to the bounding cubes. It is possible to ' overlap' objects, however this can lead to incorrect rendering of the environment. Figure 3-8 shows the effect of rotating a cube to 45 degrees, with its bounding collision cuboid maintaining its orientation, but increasing in size to encompass the object. Anything colliding with this object would stop at the blue outer cuboid (not normally visible when using VE) and not at one of the cubes faces. Placing rotated objects close to other objects can therefore cause a conflict in VRTs rendering computations. Figure 3-9 shows two rotated objects next to each other that would look flush to each other in the VE, but as can be seen the bounding cuboids overlap each other which can again causes a conflict and could cause rendering problems. Large curved or angled objects therefore have to be thought about carefully in advance and broken down into smaller objects that are correctly angled to start with in the Shape Editor.

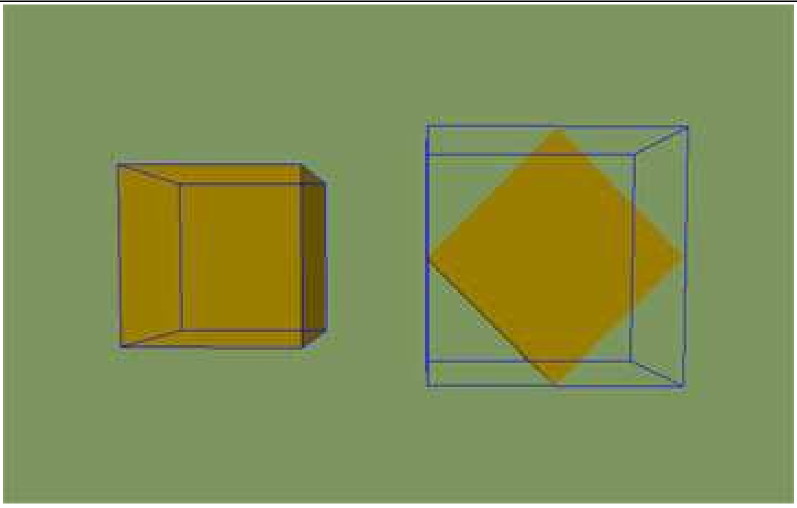


Figure 3-8: Collision cuboids of a non rotated and rotated cube.

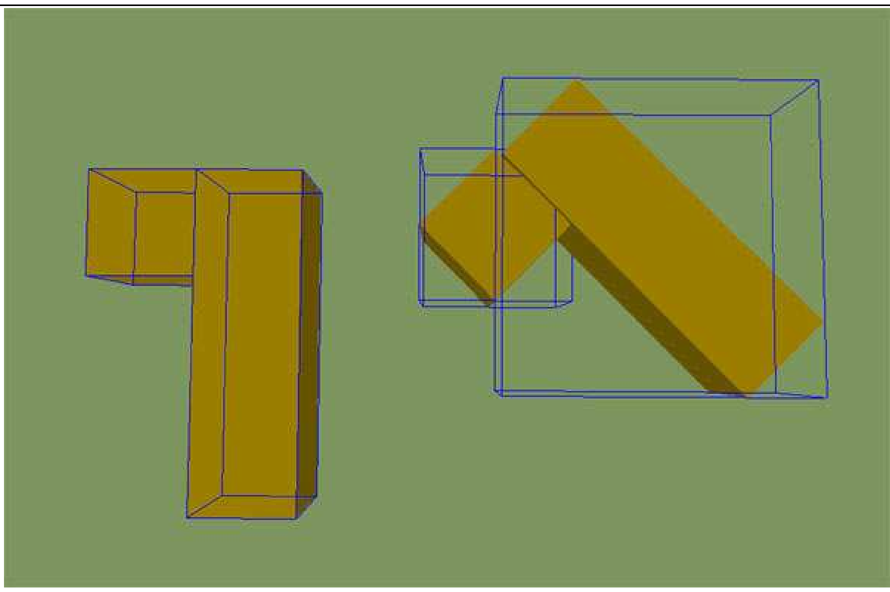


Figure 3-9: Effect of placing rotated objects next to each other.

3.2.4 Textures, Lighting & Rendering

VRT objects are initially rendered by the colours that the facets are given in the Shape Editor. The facets could have been coloured individually by the programmer or they could all be given a single colour and then a lighting effect used to subtly change the shade on the facets, so that its shape is better defined. Objects in the environment can then have their facet's colours changed in the World Editor, giving the object a current colour attribute, which overrides the shape's initial colours (given in the Shape Editor). If the current colour attribute is deleted then the object reverts to its Shape Editor colours.

VRT lighting effects take the form of having an ambient source, that lights everything evenly, a radially emitting isotropic light source or a directional source consisting of a narrow beam of light coming from a particular direction. Objects are rendered as if lit by a light with a particular intensity, colour and from a certain direction. If selected this can also render the object with Gouraud shading which 'smoothes' the object to make it more rounded instead of a series of square facets (see Figure 3-10). This feature only works if the facets on the objects have been given a 'Lit Facets' attribute

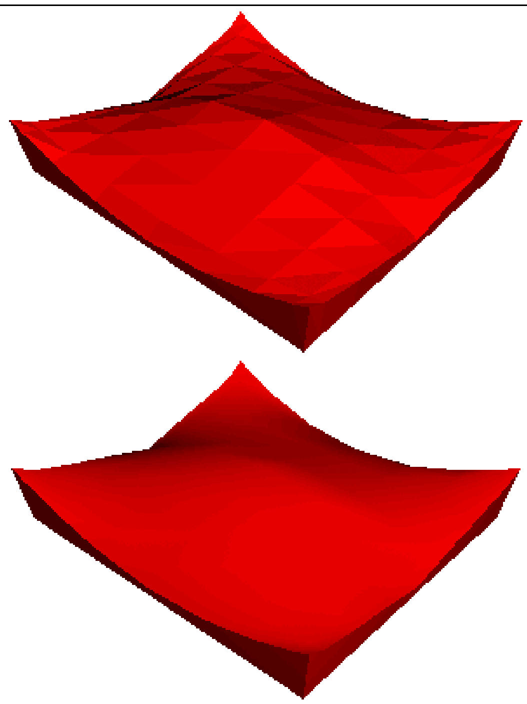


Figure 3-10: Objects rendered with and without Gouraud shading.

VRT allows photo-realistic images to be imported into the Image Editor and these in turn can be placed onto an object's facets. More than one texture can be applied to the facet, with SCL code being used to determine which texture is shown at any one time. This can be useful to give the impression of a moving or changing object such as a TV. It is also useful as any lighting effects do not alter the texture and so if you want the textured object to look different under different circumstances then the image has to be altered in a graphics package and displayed on the object at the relevant time by using SCL to control it.

3.2.5 Movement & Animations

VRT moves objects with a 'dynamics' attribute, which can either be self contained within the object or controlled by SCL code. Objects can also be moved without dynamics, by making them movable and adjusting their position every frame, which can sometimes be a more controlled method of moving objects. Dynamic objects however are needed if the user is to be controlling an object directly with an input device such as a joystick. The dynamic object is linked to a viewpoint, and will move depending on the viewpoint type, e.g. like a car, a helicopter, or a person. Rotations though will only occur if a rotational object is included as a child of a dynamic object. Dynamic objects themselves cannot be rotated, so the actual object to be controlled is usually given a rotational attribute and then a parent group for that object is given the dynamic attributes.

Objects in VRT can also be made to follow a 'path'. Various target points are chosen and the orientation of the object at each target point is entered along with how many frames it takes the object to move between the target points. The path though must be a complete loop, but it is possible to set up a straight path of movement by setting a waiting time for the last target point at a large number (e.g. a number of days) so that it does not return to its original position in the time the program is used.

Animations within Superscape are made in the Shape Editor. A number of cells are created and either points on the shape are manipulated in each cell or the first and last cells are created and the cells in between interpolated. The object in the VE is then given an animation attribute which is either a continuous movement or one controlled by SCL depending on which cell is visible at any moment in time.

3.2.6 Interaction

VRT allows some very sophisticated interaction between the user and the VE. The user can click on any object within the VE and cause a programmed event to occur. This could be just about anything from triggering off animations to controlling the dynamics of an object. Dialogue boxes can be used to pass information to the user or offer choices of things to do in a selectable menu system. The dialogue boxes can also be used to enter more sophisticated data, entering text or numbers, which can be used to control objects in the environment. A third way of interacting with the VE is through the layout editor, which creates a 2D interface around the 'window' onto the VE. This can contain a number of icons, which are always on display for the user to trigger an event or to pass information back to the user without pausing what is actually going on within the environment.

3.2.7 Multimedia

Sound can be played in VRT by importing .wav files. The files should be optimised in an audio software package beforehand, however VRT does allow cutting and pasting, frequency filtering and modifying the pitch and speed of the sounds. The sounds can then be played in the VEs by activating them with SCL and can either be played through once or looped until a condition is met. Sounds can also be made to be stereo and fluctuate in volume depending on the distance that the user is away from the object that is meant to be emanating the sound.

Video sequences can be played in VRT by utilising special driver and dll files as well as altering the VRT configuration file. These files allow an avi or mpg file to played on an assigned texture placed on a facet of an object. As VRT won't incorporate video files into the VE file, like it does with sound, they have to be stored separately on the hard disk with the VE file if they are to be played.

3.2.8 Input Devices

VRT is controlled usually with a spacemouse or joystick to navigate and a mouse to interact, although a mouse could also be used to navigate using the 'move' bar. There are a number of other input devices that are supported which only need to be toggled on the device setup screen (see Superscape, 1998).

3.3 The VIRART Approach to VE Design and Development

VIRART have enjoyed a long association with community groups and national organisations developing the role of Virtual Learning Environments (VLEs) for special education (Cromby et al, 1996, Brown et al, 1997, Cobb and Brown, 1997, Brown et al, 1999). Some of the outcomes of these collaborations have included:

- Lifestyles and Makaton – Teaching life skills such as shopping and makaton symbols.
- The Virtual Factory – For teaching danger awareness.
- The Virtual Tenancy – Teaching adults with learning disabilities their rights and responsibilities as a tenant.
- Housing Options-Teaching adults with learning difficulties what options are available to them with regards supported housing and their rights and responsibilities.
- The Virtual City – Teaching life skills to people with learning difficulties with linked modules of the home, a café and supermarket through a bus journey.

Development of these VLEs have been accompanied by a continual evaluation programme to determine their usability and the degree of transfer of this experience into real life skills (Neale et al, 1999, Standen et al, 1998). The author was involved in the Virtual Tenancy and City projects as well as Housing Options as a designer and programmer. Having a human factors as well as computing background, meant that the author did not simply rely on input from others on designing and programming the VEs, but actively got involved in the research of the project, attending steering and user group meetings as well as seeing first hand how the users were able to use VE prototypes, thus allowing for improvements to be made more easily without having to second guess what another researcher was saying. The author was therefore in a unique position to help facilitate the progress of VE development by being a bridge between the purely research based side of a project and the technical development, thus ensuring that needs and requirements were technically possible as well as suggesting alternative approaches. The authors' research and involvement with the special needs community over 9 years has meant obtaining an understanding of the people for whom the VEs are designed for with development strategies and designs evolving over this time as knowledge of the users increased. Knowing what elements of a VE work or fail means initial prototypes can be nearer the finished article with fewer evaluation/re-design iterations required, though these are always required as the needs of end users for each project can be quite different.

Brown et al (1998) show the importance of a user centred approach in project development for people with learning difficulties is well understood and documented in the special needs community. VIRART's approach to involving end-users and teachers in the development of special needs VE applications has changed over the years since its first involvement in 1991. Early VEs were developed largely through teacher involvement and suggestions, but evolved to include more and more the end user. (Cobb et al, 2001)

The framework used in the early projects was as follows (from Brown et al 1998);

User Group to determine the components developed, the learning objectives for each component, the types of interaction that are possible and the dialogue that will occur.

Steering Group to incorporate the input from experts in the learning disabilities field in the components and learning objectives of the VE.

Story-boards developed from the User and Steering Group input

Building Programme for the VEs

Expert Review of the VEs whilst under construction to ensure that they fit the original vision of the steering and user groups.

Evaluation Phase in which users and experts combine to determine the nature of testing that will help to establish whether the use of the VEs delivers the original objectives.

Refinement Phase in which the results from the evaluation phase are used to edit the VEs to ensure that the design best fits original vision.

Dissemination Phase – stakeholders involved in how best to market and publicise the VEs.

This framework still forms the basis of a user centred design approach for designing and developing VEs at VIRART, but has evolved due to differing needs and capabilities of end users. Table 3-1 shows a summary of learning VE projects over time and to what extent users were involved as well as significant outcomes learned from those projects in terms of design approach.

PROJECT	DESIGN METHODOLOGY	OUTCOME
Lifestyles and Makaton (Brown et al, 1997)	Teachers involved in suggesting learning goals, design criteria and evaluation. Users involved in evaluation of design and transfer of skills.	Series of VEs for specific learning goals – fixed design with no difficulty levels as such.
The Virtual City (Brown et al, 1999)	Users actively involved in suggesting learning goals, prototype design and evaluation testing with teacher facilitation.	Series of interconnected learning modules of fixed design and single level of difficulty. Need for greater number of modules and flexibility of environment to be familiar to users.
Radlab (Crosier et al, 2000)	Research used to identify suitable learning application. Schools involved in testing and refining VE design as well as assessing overall use and acceptability.	Single, science based application for use in mainstream schools.
AS Interactive (Cobb et al, 2002)	Teachers and autism professionals suggesting learning goals and design specification with observations of use by end users to inform design changes.	Two VEs with similar task in different contexts. Varying levels of difficulty and scaffolding. Need for greater flexibility in VEs.

Table 3-1: User input for VIRART education projects

The constantly changing approach in design, depending on the end users and learning goals has resulted in the need for a more flexible development approach, which is discussed in the following section. Neale (2001) found very few examples of people with learning disabilities being involved in practice with the design and development of computer programs and only mentions the USERfit model of user centred design with people with disabilities for the development of assistive technologies (Poulson and Richardson, 1998). The USERfit model is still the only real comparable approach, though for assistive technologies and not VEs specifically. It is a flexible toolkit for collating design material rather than a design model per se, similar to the VIRART approach as it recognises the very different needs within the special needs community (Abascal et al, 2003).

3.4 Flexible Development Approach

VIRART has developed experiential and educational VEs for a range of user groups including children with profound and multiple learning disabilities, teenagers and adults with moderate learning disabilities as well as mainstream students. VIRART has always adopted a user-centred approach to design, although this has not been a rigid method, but a fluid, dynamic process; evolving with each successive project taking into account different needs, abilities and communication skills of specific user populations. This approach is presented as a 'toolbox' of techniques which may be applied at appropriate stages within the design lifecycle, dependent on the assessments made by the user-centred design facilitator. The toolbox of techniques includes a variety of methods for gathering, evaluating and applying information contributing towards virtual environment design. These are grouped into three main areas: Design specification, Guidelines and Prototyping as described below (Neale, Cobb and Kerr, 2002).

3.4.1 Design Specification

As Virtual Reality is still a relatively new technology, there is often no previous information concerning design of VEs for a particular user population. Therefore a first step is to demonstrate existing VEs to these user groups and professional representatives (e.g. teachers, domain experts, training advisors, support workers), followed by a review of the usability, acceptability and appropriateness of these VEs and specific features of them for the particular user population. Techniques applied in order to determine the usability and user opinions of a VE include observations of their use in a particular task, measuring the level of support required and contextual interviews augmented by the technology (e.g. user review of VE design using on-line walkthroughs). These must be adapted based on individual ability levels and may require facilitation by a user advocate (Neale et al. 1999). Techniques involving professional user representatives include workshops where the potential of the technology is emphasised and existing programmes can be used and discussed by attendees, with questionnaires and interviews used to identify potential training uses and educational content of a new VE.

3.4.2 Guidelines

Wilson et al (2001) argue that many existing guidelines and models are not always useful for VE designers as they specifically refer to WIMP (windows, icons, menus and pointers) interface based styles and new useful guidelines are not always easy to produce.

Fencott (1999) describes the principle difference between WIMP interfaces and VE interfaces; the former is static, and the latter is dynamic, and an interactive object in a VE may be viewed from many different angles and distances. Kaur, Maiden and Sutcliffe (1999) identified three modes of interaction in VEs:

1. Task action model – purposeful behaviour in planning and carrying out actions as part of the user's task or current goal and evaluating success of actions.

2. Explore navigate model – opportunistic and less goal-directed behaviour when the user explores and navigates. The user may have a goal in mind or else observed features may arouse their interest.

3. System initiative model – reactive behaviour to system prompts and events and to the system taking interaction control from the user.

Kulwinder Kaur's PhD research into user interaction in VEs, resulted in the development of generic design properties that could support generic models of behaviour in a VE (Kaur, 1998). These were developed into design guidelines to support usability considerations in interface design including, design advice, motivation, context of use, and practical examples. A selection of these were presented as a hypertext tool to be used by designers throughout the VE development process. One of the strengths of Kaur's work was that she concentrated on how the guidance may be used to inform the actual development of new environments, and by examining the design practice of VE developers she presented this information in an informative and useful way. Although an empirical study demonstrated that these guidelines seemed to be a useful tool, there has been limited take up of them by the wider VR community. This is possibly due to the guidelines being based on theory and that some of the guidance provided may not be appropriate for different VE designs, application type, or user population.

Even though there are usually no specific guidelines available for a particular user group, existing general interface usability guidelines can be combined with guidelines for VE design such as those presented by Eastgate (2001) to inform many aspects of the VE design and at least form the basis for design. For example, Neilsen's ten design principles (1994) and Schneiderman's eight golden rules of interface design (1998) can be useful in VE design as there are many common issues that affect both a VE and a 2D interface with regards to the need for the user to access information. These guidelines can be incorporated along with the experience gained by the VE developer in developing similar VEs, along with reviews of background literature about the target users, to establish general points for consideration in a design. This also shows that it is important to use a multi-disciplinary approach to the development of the VE, so that all aspects of the interface design requirements are represented.

Eastgate's (2001) Virtual Environment Developmen t Structure (VEDS), is a model that outlines the numerous stages of decision making that VE developers will face providing them with relevant assistance at each stage. The model is aimed at developers of VEs and is presented in a predominantly diagrammatic format, allowing developers to work their way through them, making decisions at appropriate stages of the design.

The seven main stages of VEDS are; Specification, VE Overall Design, Resource Acquisition, VE Design Detail, VE Building, VE Testing and Implementation. The detail of VEDS can be seen in Figure 3-11.

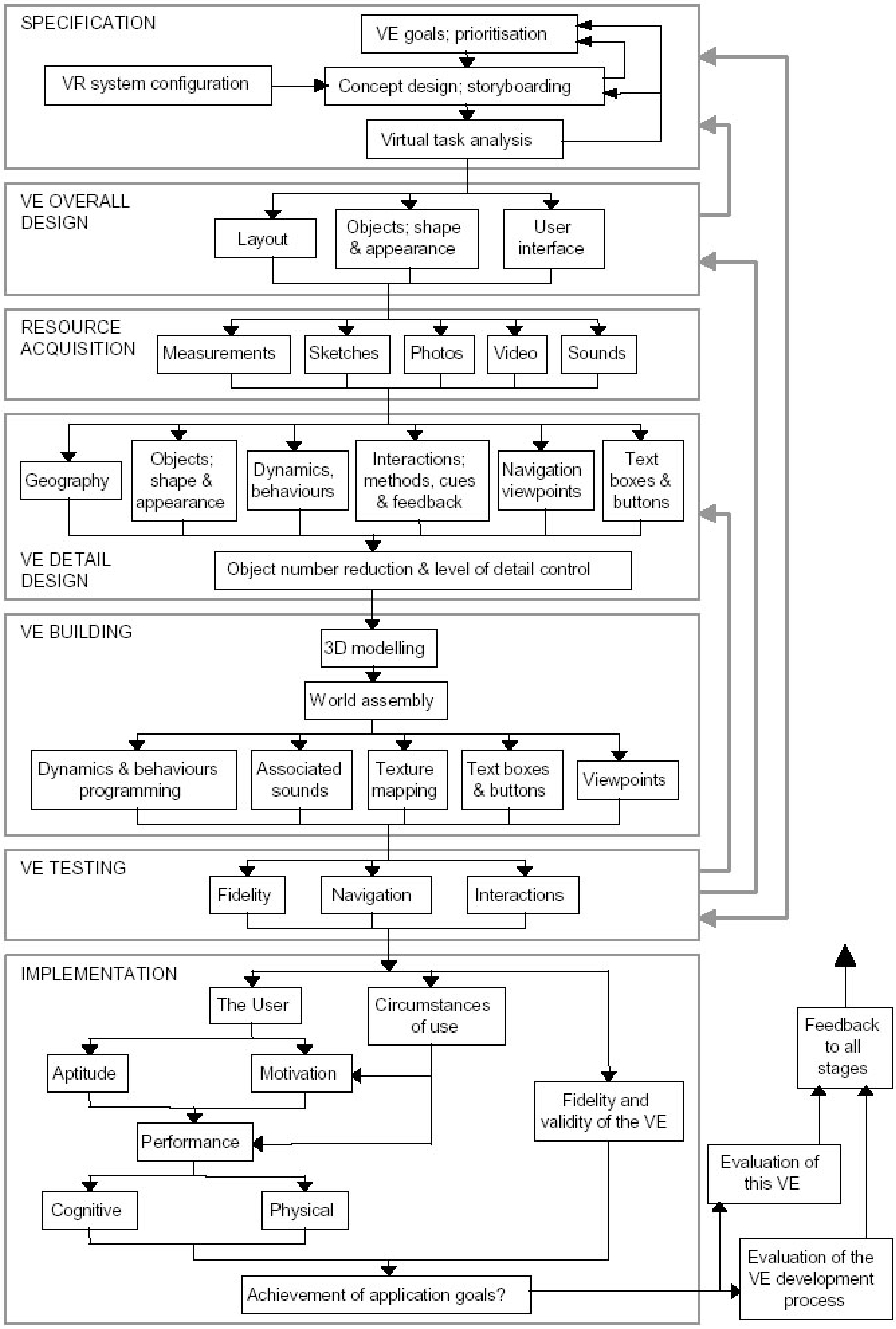


Figure 3-11: VEDS Virtual Environment Development Structure (Eastgate, 2001)

There are also some guidelines for specific elements of a VE (Marshall, 2005; Griffiths, 2001). Griffiths (2001) found that the detail level within a VE influences performance, with a high detail environment being more conducive to the proficient performance of tasks which require accuracy, such as certain aspects of navigation, whilst a low detail environment allows for the efficient completion of tasks such as interacting with specific objects within the VE (more clearly seen and easily selectable). He also looked at "floating interfaces" as oppos ed to interfaces external to the VE to ensure that the user remained "within" the VE itself and did not feel removed in any way. However floating interfaces may block the users view of objects within the VE so he recommended having a level of transparency. Making the floating interfaces semi-transparent would grant the user an uninterrupted vision of the VE, thus enabling them to read the information clearly, whilst concurrently remaining focused within the VE itself. Griffiths also believed that more attention should be paid to gaming technology when looking at interfaces, with dynamic interfaces that bring up actions as required being very popular.

Marshall (2005) investigated the most effective prompts to selection of specific objects within a VE. She found that the more realistic the environment, effective cues should be incongruous to the surrounding VE such as primary coloured flashing cues and that using the same type of cue throughout was more effective than having a variety of cues. In such circumstances she also found that using cues prompted greater selection than not using cues at all. When the VE is less realistic and more abstract however then the effectiveness of such cues is diminished. If the user is not performing a task then they explore the VE more and select many objects, especially if they are cued. She also found that tasks may detract a user from recalling objects they had previously selected as they were concentrating so much on the task though increased selection of an object (helped through being cued) increases the chances of the object being recalled.

3.4.3 Prototyping

One of the techniques used to aid VE design planning is to construct early prototypes. Prototyping can include paper-based methods as well as initial VE programs. 2D prototypes are most useful in early discussions with teachers and professionals associated with the target user group to define functional aspects and generate the learning objectives for tasks to be performed in the VEs. A drawback though is that they do not easily represent potential user interaction within a VE and therefore 3D models can be used instead to determine the layout of a VE and how the user might interact within it. VE prototypes go a step further and are early versions of the proposed VE with incomplete content and functionality. These prototypes are extremely useful for formative evaluation of VE development and facilitate direct user involvement in refinement of all aspects of design specification. Multiple activity analysis applied during user/facilitator trials can then be used to determine how and where the user requires additional support or prompting from the system (Neale, Cobb and Kerr, 2002). This involves potential users carrying out related tasks, using interaction methods and metaphors envisaged to be in the fully developed learning program and observing where they have difficulty and how severe the situation is by the amount of help (as well as the type of help) they require to complete a task.

3.5 Usability & User Centred Design

Usability is often referred to as the process or study of making the system useful and usable. Usability is not something that just happens as a result of a unique strategy or process, but with the involvement of the users at some stage in the process of development (Preece et al., 1994). Usability and user centred design are not exclusive to the academic community and has been widely adopted for commercial software development.

For example, the Microsoft website (http://www.microsoft.com/usability/faq.htm) describes their approach to development of new software with their Usability Group forming an integral part of the design process. Their usability engineers observe user behaviour with pre-released software, recording and analysing how the software is used. This information is translated directly into product design improvements by usability engineers, user-interface designers and other product team members. Though the majority of their product evaluations are one-on-one observational research, usability engineers actually employ a wide variety of experimental methodologies to address the breadth of design questions that arise. For example, usability engineers are also involved in;

- *Field research (nationwide site visits)*
- *Expert reviews (heuristic evaluation)*
- *Focus group research*
- *Competitive product research*
- *Children' s product research*
- *Hardware research*
- *Paper Prototype research*
- *Co-discovery sessions*
- *Product Support research*

(from Microsoft, 2005, http://www.microsoft.com/usability/faq.htm)

As shown above, there are many different ways in which user-centred design may be defined and carried out, Preece et al (1994) highlights some factors that should be common to all of them:

- User-centred and involve users as much as possible so they may influence the design
- Integrate knowledge and expertise from the different disciplines that contribute to HCI design
- Iterative testing to check the design meets user requirements

User-centred design may be presented as methodologies (Gould, 1988) but more frequently as a set of principles or guidelines (e.g. Schneiderman, 1998). Karat (1997) looks at some of the various opinions and approaches taken by practitioners of user-centred design and concludes that there is general agreement on the principles of user-centred design, yet there is no broad agreement on the techniques to be used to achieve these principles. The amount of direct user involvement in the design process is not clear. Generally, the design may be 'centred' around the user, but this may mean just making sure the user is accounted for when making design decisions rather than their direct involvement.

It is acknowledged that end-users should be able to inform the design team of what constitutes effective motivation and learning methods within a program, and that teachers and educators are better placed to inform designers about educational goals

(Crosier et al, 2002; Scaife and Rogers, 2001). Neale, Cobb and Wilson (2001), report that user-centred design aims to involve users in the development process as much as possible. Some approaches to user-centred design such as co-operative or participatory design, involve users as active collaborators or partners in the design process (Bodker et al, 2000). As well as ensuring that the technical system meets user and task requirements, this type of approach also ensures that the system will fit into the context of use, taking into account social and organisational factors. Chappell (2000) reports the recognition that people with learning disabilities are capable of insight into and analysis of their experiences is relatively recent, as is their role in participatory research. More recently, Mathers (2004), notes that while more and more people with learning disabilities are participating in the decision making process about things that affect their lives, they are not always central to the process and their point of view may not always be understood due to a failure to communicate in an accessible manner. Similarly, Neale, Cobb and Wilson (2001) point out that due to the specific requirements of a learning disabled population, some of the methods most commonly used in HCI evaluation could not be used or have had to be adapted in order to be applicable. Iterative involvement of representative users has been critical to the design process, however care must be taken to ensure that we truly are accessing opinions of users and not just the views of the professionals that work with them. The methods used to facilitate user involvement in the design process need to be appropriate for both the user group and the technology worked with. Bodker et al (2000) emphasise the importance of seeing the conditions of the participatory design process from the point of view of the users as well as the researchers.

3.6 Research Theory

The theories presented in sections 3.6.1 and 3.6.2 (grounded theory and action research) describe two commonly used methods for carrying out research in practical situations, e.g. in a software application development project. A research project may involve finding out more about the user, elements of the software or how the software is used and therefore affects the whole design development process. Section 3.6.3 concludes with an overview of what elements of these theories are applicable for the research carried out in the AS project.

3.6.1 Grounded Theory

Grounded theory takes an open view to gathering data. It is largely ethnographic and looks at ways of analysing data rather than gathering it. Questionnaires can be formulated based on data already gathered (Charmaz, 2000). An important distinction between case research and other empirical methods is that the variables of interest that explain the phenomena are not identified prior to the study. Both variables and the relationships between them emerge as the data is collected and analysed (Sherif and Vinze, 2003). In other words, grounded theory encapsulates an evolving process of data gathering or an iterative process where each successive stage is based on the findings discovered previously.

Grounded theory places emphasis on conceptualising participants' accounts of experiences and events to explain a process (Scott and Kaindl, 2000). Grounded theory is appropriate in the early stages of research on a topic, because it is inductive and does not rely on previous literature or prior empirical evidence (Eisenhardt, 1989).

Sherif and Vinze, (2003) give an example of grounded theory in use for understanding the factors governing the reuse of software. Their research started with an initial round of interviews, with new sets of questions added in later rounds to reflect additional concepts that emerged. Follow up interviews were then conducted to collect data on emerging concepts that were not considered in the original interviews. Concepts were grouped into categories, a process known as selective coding. Occasionally, new categories were added and others were regrouped when transcribed interviews were analysed. In other words, while there were specific elements targeted by researchers for analysis, many variables of research were not identified until initial data was collected, evolving over time as the researchers gained more knowledge. This approach is considered legitimate in grounded theory methodology and has been successfully adopted in IT research.

3.6.2 Action Research

Action-research is a form of inquiry in which the investigation itself is embedded in the object of inquiry. Much like participant observation and ethnographic analysis, the researcher in action research is a constituent element in the target situation. (from Tinker and Feknous, 2003).

Participatory Action Research (PAR) is a collaborative approach to conducting research that can be used in both qualitative and quantitative research. Time, money, and interest make it unlikely that all individuals affected by a proposed project will be able to participate in it; however, it is imperative that all stakeholder groups be represented. Naturally, the extent of participant diversity will be dictated by the research question. If the research question is specific to a certain group, members of this group should be predominantly represented. If the research question is general, then participant diversity in terms of type of disability and cultural background should be sought as it may result in more accurate representation.

One of the objectives of PAR is decentralization of knowledge so that knowledge is shared by the team members. The goal of PAR is to reduce or eliminate the gap between the outsiders (researchers) and insiders (collaborators), and between research and practice. The assumption is that each member of the research team has different areas of expertise (White et al, 2004). PAR is low tech, sacrificing methodological sophistication in order to generate timely evidence that can be used and further developed in a real time process of transformation (Kemmis and McTaggert, 2000), i.e. it is good for getting large software projects moving.

3.6.3 Applicable theory for AS project.

Elements of both of these approaches were suitable for the AS project. Grounded theory method was suitable for the AS project as there was no previous data on how to design VEs for people with AS and so a 'best guess' for the design had to be informed through previous knowledge and research of similar VEs and an understanding of the new (to the VE research team) user population. User group testing provided us with knowledge and ideas not previously understood which in turn determined the research and development path taken. Action Research was suitable as the different members of the AS project team met regularly to discuss what they were doing, their ideas or findings and so each could understand what everyone else in the group was doing as well as actively contribute to their work if necessary. The researchers went regularly to the schools where the software was being tested and did not just purely observe the group but became part of the group when using the software, especially when helping the users understand what was happening in the scenario as well as how to use the interface, though sometimes the teacher would re-explain these things in a way the user might understand better. Getting quick and frequent feedback from users in situ means that progress can be made on the complex environments, especially as there was a time (3 years) and cost (no other programmers or researchers could be drafted in to help) limit on production, which was important if the project was not to stagnate.

3.7 AS Project Approach

3.7.1 Inclusive Design Approach

As mentioned earlier, VIRART's approach to VE development is user centred. Involvement of professional and user representatives in the design and review process is essential to ensure that the final VE design is acceptable to students and teachers alike, can be easily used by them and provides support for the training requirements of the students (Rutten et al,2003). Even if it is not possible or appropriate for the end user to actively come up with suggestions about learning objectives, their involvement can be more than just testing a VE with facilitated discussion groups exploring what is good or bad about development prototypes.

As far as possible the methods used in this research are best conducted within the intended context of use. Ethnographic methods of enquiry should be used to observe teachers and students using the VEs in the classroom to inform ongoing development and review of VE design regarding utility and usability of the programs (Neale et al, 2002). Whilst the author and researchers did go to schools to test the use of the VEs and actively take part in the use of the VEs, this was not strictly the same as PAR, but as mentioned in section 3.4, a toolbox of methods was applied, taking relevant parts from different methodologies. In the AS project a combination of objective and subjective measures to inform the design of the VEs was used. The majority of formal testing was undertaken by other members in the project team while the author was primarily interested in the observation of use of the VE, although the author also obtained specific information from teachers through questionnaires. At the same time, members of the team from psychology, amongst other things, examined in more detail some objective matters such as the recognition of VEs as representing something real.

3.7.2 Collaboration

An essential component of the research in the AS project was collaboration between organisations (Nottingham University and the NAS) and disciplines (computer science, human factors, psychology and autism).

"*The nature of autism often requires an interdisciplinary approach; the complexity of the disorder, the individuality of children and adults on the spectrum, the diversity of the manifestations of the disorder, the range of the spectrum – these are all ingredients which call for multi- and interdisciplinary approaches when working alongside the child or adult to allow for optimum support.*"(Beardon et al, 2001).

Members of VIRART had to combine their technological skill with their newly acquired understanding of ASDs in order to develop systems which not only fulfil the requirements of a VE, but are user friendly for the ultimate user group. This could only be achieved by relying on true collaborative working between all members on the project team.

In order that the VEs were built efficiently, and with the greatest potential for beneficial use, early stages of the research included partnership working with people with AS who were recruited to advise on the development of the systems. All users involved in the commentary had a diagnosis of AS, and were recruited based on their interest shown in the project after reading a description of the research passed to them via a social group co-ordinator (Beardon et al, 2001).

3.7.3 Review Existing VEs

As there was no previous information about how to design VEs for people with AS, it was not known how this user population would react to VEs. There was a need therefore, for some existing VEs to be reviewed to identify any particular aspects of VE design that need to be adapted, added or omitted for users with AS. VEs to be reviewed should be relevant in some way to the current project either in terms of content, learning style or learning goals so that informed decisions can be made. A VE thought to meet this criteria for the AS project was the City Café, designed to allow the practice of daily life skills for people with learning disabilities (Brown et al, 1998), which although not specifically designed to teach social interaction skills, was thought to offer the most potential for social interaction of existing VEs which could be looked at.

After initial modifications were made based on the recommendation of the autism practitioners, the reviewed VE was then shown to potential users for comment and informal assessment. A series of evaluations of the City Café took place using questionnaires to look at levels of enjoyment and good and bad aspects of the VE. A continuous programme of evaluation and redesign was then conducted to evolve the VEs, taking into account the comments made by the social group members and any areas highlighted through observation analysis by the research team. This process is described in more detail in section 4.2.1.

3.8 Iterative Design Process

3.8.1 Overview

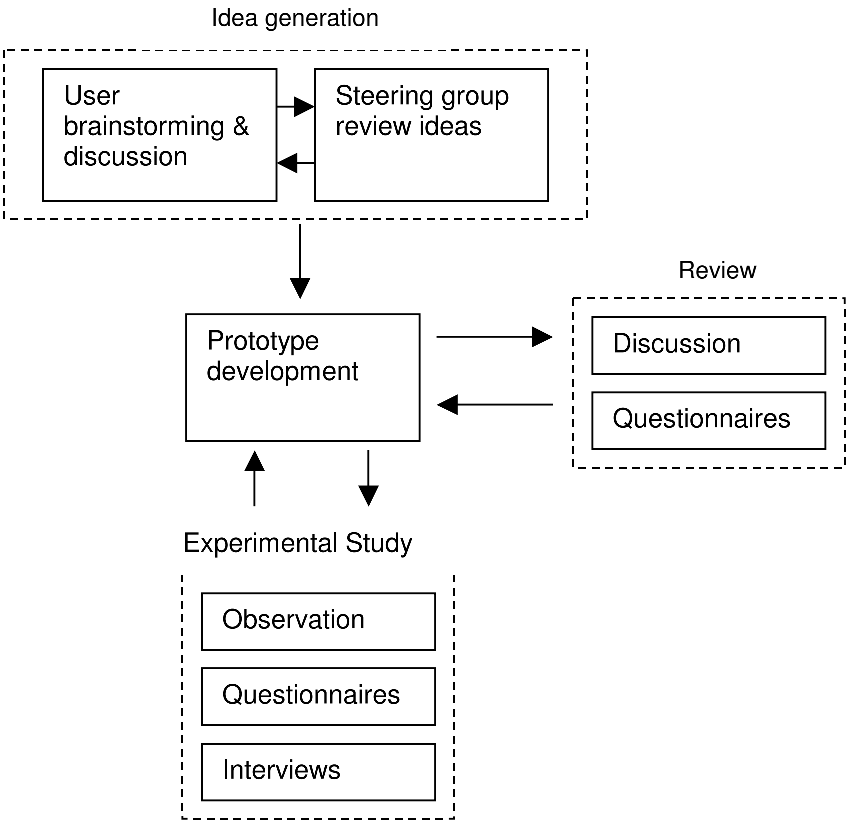


Figure 3-12: User Centred Development Process (Neale et al, 2001)

Figure 3-12 above, shows the overall design/development process used by VIRART in the AS project. Professional stakeholders such as teachers and autism experts came up with learning objectives in combination with users and provided ideas for the VEs. Storyboards and 3D models were then developed and reviewed by the experts before prototype VEs were built. These in turn underwent a succession of expert review through discussion and questionnaires before being tested on users. Testing was in the form of observations, interviews and questionnaires (Neale et al, 2001).

From a developer's point of view, information required to program a VE is needed in the order shown in Table 3-2. As the setting of the learning VE is decided upon early on, this allows the developer to build the objects and layout of the VE whilst decisions can be made about the functionality and structure of the learning experience.

Design Element	Description	Tools
1. Content	Objects that appear in VE.	Pictorial storyboards Hand drawn picture storyboards 3D low-tech models
2. Layout	Where the above objects go.	Pictorial storyboards Hand drawn picture storyboards 3D low-tech models
3. Function	Interactions (whether through a mouse click or navigation.)	Written storyboards Pictorial storyboards Hand drawn picture storyboards
4. Structure	Reactions to function in form of events, feedback or learning objective timeline.	Flow diagrams
5. Interface	Additional buttons, text and audio for aiding user in task.	Mock-up diagrams

Table 3-2: VE design and development stages.

3.8.2 VE Design

Brainstorming and storyboarding techniques can be used with groups of representative users or domain experts to specify VE content. In the case of the AS project where it was not practical for the end users to contribute to initial design decisions, these were made by the domain experts and developers. However some users who were capable of dealing with abstract ideas, could provide comments about the early designs with the help of a facilitator. As well as verbally discussing ideas, they were able to represent their ideas pictorially on a flip chart. A member of the human factors team in VIRART worked closely with the experts and user groups to form initial storyboards for the VEs and these were discussed with the programmer to determine what is possible in the given time as well as suggest possible alternatives to the design (Neale, 2001e).

A number of iterative steps may take place in the design process as feedback from experts and users is channelled back to the VE development team and back again to the experts and users in a continuous design cycle. There should however be enough detail from the very first designs which can allow the VE programmer to begin producing 3D objects and the layout for these objects in the VE. Animations, textures, some sounds and even some functionality specific to objects already identified as required in the VE can be worked on, though the programmer has to be aware that they should leave most of these aspects to last as they may need changing if the design changes. It is really in the judgement of the programmer (using knowledge of why certain elements were chosen in the first place) as to what can be reasonably expected to stay the same, even if changes are made to the design.

3.8.3 VE Development

Development begins with the construction of prototypes, which as stated previously, are early versions of the proposed VE with incomplete content and functionality. Representative users and domain professionals review VE prototypes at different stages of the VE development cycle. Early prototypes are reviewed through demonstration and use followed by direct discussion with the VE developer. This provides initial, direct feedback about acceptability from users and usefulness in terms of its application from experts. Later prototypes are reviewed in a more formal manner, where tasks within the VE can be set and questions directed at particular aspects of the environments. This allows for a more in depth review to take place that focuses on specific aspects of the VEs as directed by the instructions given.

Informal prototype reviews with representative users and professionals allow VE developers to directly observe and talk over any problems of VE suitability with the end-users. This direct feedback mechanism means that this process was quick and effective at highlighting any major problems.

3.8.4 VE Evaluation

During the later stages of development, a more structured review session allows the VE development team to focus on specific features of the VE and get responses to these particular features from domain experts and users. This method is similar to the predictive inspection methods carried out by HCI experts, with the involvement of professionals that work with AS in order to take into account the abilities and training requirements for that group (Neale et al, 2001).

Observation methods are usually heavily relied upon for evaluation of VEs with special needs user groups. This method allows for the collection of a great range of data, from the number of attempts a user takes to carry out a task to qualitative descriptions of how the task is carried out. Observation data was particularly important in the AS project, where self-report data was limited, although this was time consuming to analyse (Neale et al, 2001).

In this type of research it is difficult to access users true opinions as none of the standard questionnaires used to assess the VE experience were suitable for use with the AS user group. Therefore researchers in the AS project had to adapt and create new ones. These were often difficult to implement, as the users were generally more interested in carrying on with using the VE than listening to the researcher and answering questions and even though the questionnaires had been adapted for the user group some of the users still found the questions difficult to understand; their support workers sometimes having to re-iterate the question or prompt answers from the user (Neale et al, 2001).

3.9 Summary

This chapter has looked at the methodology behind designing and developing VEs for people with special needs. The approach used by the author from a historical and current perspective is given to show how it evolved, encompassing user centred design. The flexible design approach discussed centres around understanding the user and using appropriate guidelines to inform the design of prototype VEs and conforms with action research and grounded theory. The overall methodology used in the AS project is then discussed highlighting its collaborative nature and inclusive design approach using reviews and user evaluations of existing VEs to start the iterative design process which is a continuous process of design/develop/test/refine. The design elements that the VE developer needs to consider are also looked at and the information they specifically require when working as part of a large multi disciplinary project team.

Chapter 4. Development of Virtual Environments for Social Skills Training

4.1 Introduction

This chapter describes the beginning of the development phase of the research where the first prototype VE was built. Following the methodology laid out in section 3.7, this phase began by looking at how previous computer programs and VEs had been used to teach people with autism as well as examining what features of VE learning scenarios already developed by the author and the research group in previous work could be used for this specific project. This early review of VEs was conducted by the multidisciplinary research team comprising VE developers, human factors researchers, psychologists, computer scientists and autism professionals, with observations of VE use by representative end users drawn from AS social groups and autism teachers to obtain their initial thoughts on what elements of VEs could be used successfully by their students.

Information gathered during this process was used to inform the design of the learning scenarios. A series of training/evaluation programs and prototypes were then developed, following a design/build/review iterative process, and this chapter describes the key stages of this development. It should be noted however that there was constant refinement of features in the prototype due to everyday discussion and feedback between different members of the research team, which are not discussed in this chapter. In particular, the author worked closely with the human factors experts, brainstorming ideas and if required, involving other members from psychology or calling up teachers for advice. This was due in part to the implementation of recommendations that in turn raised other issues, which were apparent before any testing was carried out. These informal changes were evaluated at the end of each iterative stage and any consequences from them are reported here.

Figure 4-1 shows an overview of Chapter 4, detailing where research informs the design and development of the café VE prototype. Observations, workshops and guidelines taken from the literature review in Chapter 2 were used at different stages of development, depending on what features were being added at that time. A review of existing VEs led to the City Café being observed in use by potential end users and reviewed by teachers in a workshop. Teachers suggested learning scenarios (as further developed in the SVE Design Specification) and other features developed in the first prototype, while findings from both observations of the City Café and first prototype were used to develop the next level prototype, improving on existing features and adding scaffolding and training.

This chapter details the program of construction of the VE prototypes. The design, review and redesign of the VE prototype is then discussed before looking at recommendations for the next stage of research and development.

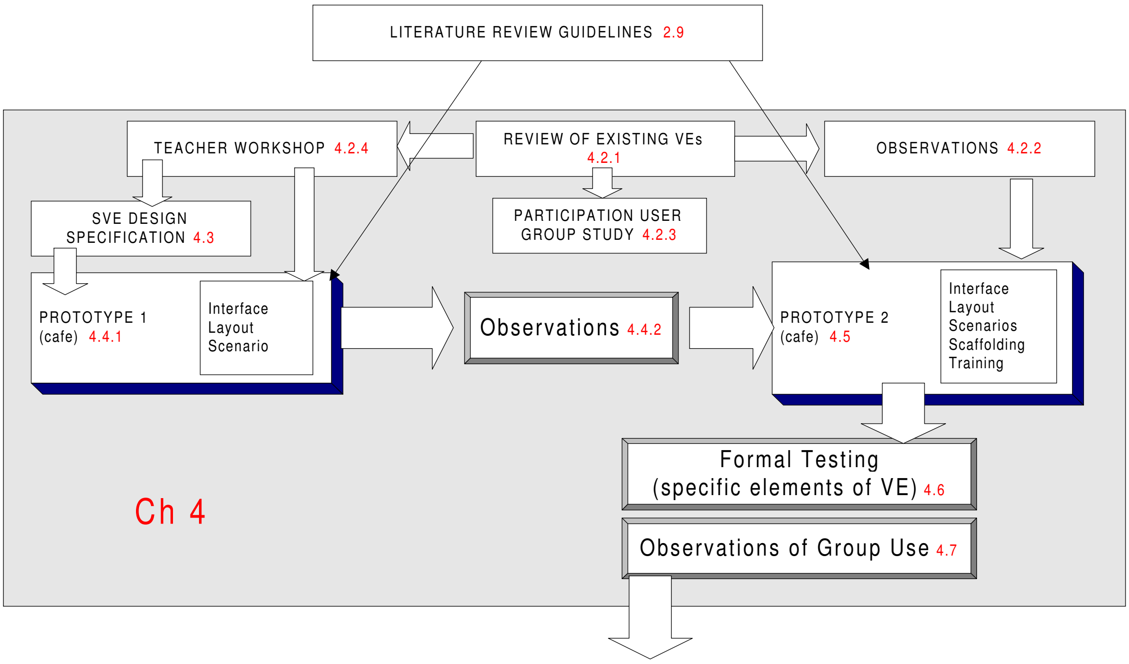


Figure 4-1: Chapter 4 Overview

4.2 Identification of Requirements

4.2.1 Review of Existing VEs

In section 2.3, a review of existing VEs showed that there were very few VE applications for people with autism (the majority of learning software being 2D multimedia) with none of those being aimed at teaching social skills. However existing VEs that offer similar functionality to that required in the AS project could be examined to determine useful features for a new VE as described in Chapter 3, section 3.7.3. The author had been involved in developing VEs over the previous 6 years with the Virtual Reality Applications Research Team (VIRART) at the University of Nottingham who themselves have over 10 years experience in the field. It was felt that while the needs of people with AS would be different to previous projects, many of the basic features of VEs would be useful to this project, so reviewing some of these existing VEs would be a good place to start. In particular, a series of VEs called the Virtual City, recently developed by VIRART, (2 of the environments created by the author) were examined by the project team.

The Virtual City, was designed for children and adults with learning disabilities to learn and practice a series of everyday skills leading towards independent living (Brown et al, 1998). Scenarios within this programme represent procedures and task sequences such as selecting items in the supermarket and paying for them, planning for a bus journey, ordering food and drinks in a café and preparing a meal in the home. These VEs were implemented using Superscape VRT and run on regular desktop Pentium PCs. The AS project team decided that the café environment (see Figure 4-2) would be the best module to act as a test case for the AS project, because it represented a social environment. Although dynamic interaction between characters in the Virtual City café was not available, it offered potential for virtual social interaction and could allow the development and refinement of target social skills before work-related environments were produced. The café was also an age appropriate environment given that both adolescents and adults would be using it.

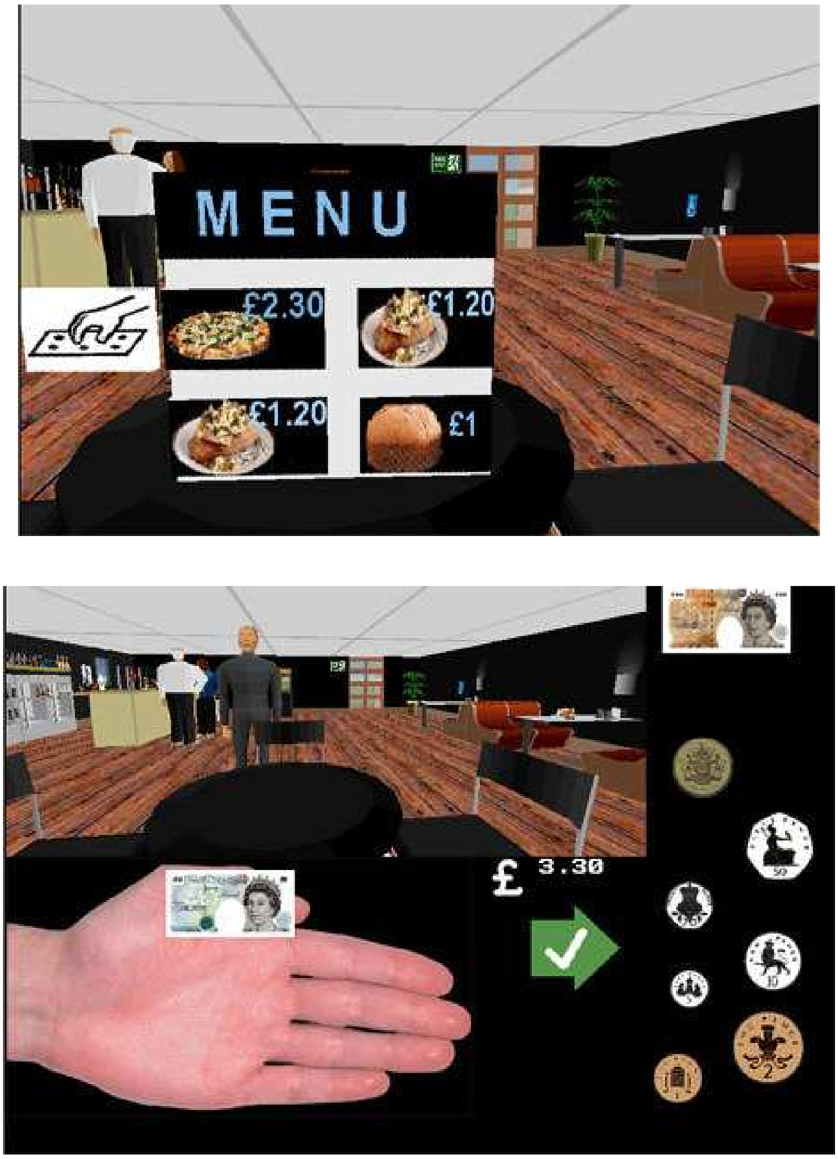


Figure 4-2: Virtual City Café

A user can perform a number of different tasks in the café, including sitting at a table, ordering food from a menu, ordering and paying for drinks at the bar and using the bathroom facilities. Instructions to users within the café appear in pictorial, written and/or spoken format. Movement around the café is achieved using a joystick and items (e.g. how much money to pay the waiter) are selected with the mouse. The autism training professionals in the research team used this VE and recommended changes to be made to the VE, to make it more appropriate for the AS user group. These changes were discussed with the whole research team with suggested changes including: the replacement of strongly coloured textures with more subtle ones, the replacement of communication symbols with text, and the facility for the user to choose the way in which prompts are presented to them. Some of these changes were then implemented in the City-Café before it was presented to a group of representative users (Neale, 2001b).

4.2.2 Observations

Observations of use of the Virtual City café took place in Sheffield with a user group organised through the NAS. User comments were recorded and users were also given a short 'computer use' questi onnaire to assess their level of familiarity with computers. There were two sessions to the observations with the purpose of the first to allow familiarisation with the VE and to gauge general ideas about problems and design issues. The second sessions would involve asking a number of specific questions tailored to users comments or difficulties noted in the first session. More detail of these observations are in Neale et al (2002b) and Neale (2001e).

The user group carried out a pre-specified set of tasks in the VE and their actions were observed. Interviews were also conducted. Most users carried out tasks correctly and required little assistance from the researcher working with them. However a number of critical incidents were observed. A critical incident may be described as an occurrence in task performance that indicates a usability problem. Usability problems were identified associated with navigating around the VE, interacting with objects within the VE and understanding communication from the VE. By specifying what these particular problems were they could be avoided in any new VEs developed for this user group. When asked, most of the group very much enjoyed using the VE, but commented on a number of factors that they thought could be improved. Their answers fell into 3 categories: *reality* - the characters in the VE should be less ' blocky', *functionality* - there should be more things to do, and *interface* - there should be more prompts for the user (Neale, 2001b).

4.2.3 Participation User Group Study

There was a formal assessment of the use of the original Virtual City café (with slight alterations as discussed in section 4.2.1) by a group of adolescents with AS to gain a clearer idea of how they interacted with VEs compared with other groups of users, including students with learning disabilities, and normally developing adolescents. Additionally participants with AS were tested by the psychology members of the AS project team on a number of standardised assessments in order to see whether particular profiles of cognitive ability were predictive of performance in the VE. Basic, but crucial issues investigated were:

- Can people with AS use and understand the VE sensibly?
- How do they behave (verbally and non-verbally) when using the VE?
- How do they treat the 'people' within the VE?
- Is there something specific about VEs that makes them particularly easy/difficult for people with AS?

12 pupils at Rosehill School aged 13-18 years were matched to two other pupils from different schools, one on verbal ability, the other on performance ability (see Parsons et al, 2004 for more detail). The majority of participants who were matched on verbal ability came from Special Needs Schools while the rest came from mainstream schools. These participants were shown how to use the joystick to navigate and the mouse to select objects in a VE. They then received 4 trials using a training VE (see 4.2.3.1), during which they had to navigate through open and confined space before carrying out tasks in the Virtual City café (see 4.2.3.2). For more detail on this study, please refer to Parsons et al, (2004). Results from these studies are discussed in section 4.2.3.3.

4.2.3.1 Training Environment 1

This environment was used to train users in navigation and interaction within a VE, using an appropriate input device, in this case a joystick and mouse, to get participants used to using the equipment before entering the Virtual City cafe. They also enabled researchers (psychology and human factors) to investigate how well participants responded to different task demands in the VEs, such as navigating through open and con• ned space, completing a search task, and check whether performance changed over the course of the trials. The user would first navigate around a building before entering into a maze like corridor. Arrows on the walls show which direction the user is meant to be going, aiding the user if they get disorientated (Figure 4-3). The next task was for the user to search within the VE for a number of randomly selected objects in a sequence that was shown to them beforehand on pictures. These objects would be hidden in boxes and could only be seen when the user was close to the box, thus forcing them to explore their surroundings, trying to remember where objects were. Clicking on the object would remove it from the VE while its image would appear at the bottom of the screen (Figure 4-4). The user would have to match the pictures at the bottom of the screen to the sequence they were shown beforehand. Clicking on the picture would remove it while returning the associated object to the VE.

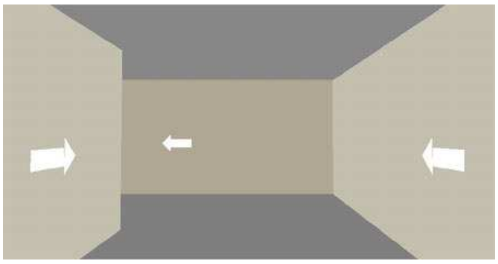


Figure 4-3 Arrows on 'maze' walls.

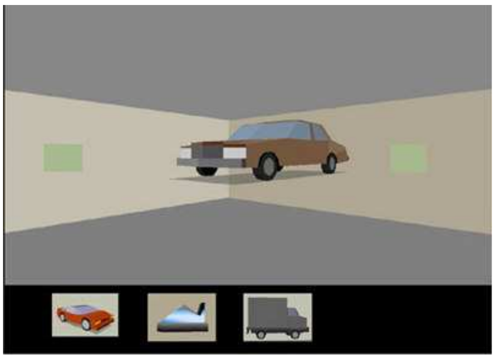


Figure 4-4 Collecting objects in main room

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4.2.3.2 Virtual City Cafe

After completing the training trials, participants were given an opportunity to use the Virtual Cafe´, an environment taken from the Virtual City of the Life Skills Project (Brown et al., 1999). This environment was developed to support the learning of daily skills in people with general learning disabilities. Differences between this and the training environment are that it looks more 'realistic' through the use of textures and images, there are people in the environment and textual and verbal prompts as well as visual cues such as flashing areas of red are used to guide the user. Participants were told that there were different tasks to be completed in the cafe. They were shown a checklist of tasks, and were told to complete the tasks in the order they were shown. The checklist was visible throughout the session and listed the following tasks:

- sit at the black table;
- order some food and drink from the menu;
- pay for the food and drink;
- order a drink from the counter;
- pay for the drink.

Each task involved a number of subsidiary stages, which can be split into three different types:

1. Communication—the computer asks the user a question, handles responses from users and provides feedback.
2. Interaction—the participant uses the mouse to interact with a part of the screen (e.g., responding to a question, or making a choice from the menu).
3. Navigation—the participant uses the joystick to move from one area to the next, within the environment.

Participants received minimal prompting throughout their use of the cafe´ environment. If participants asked about the next task, they were directed to read the checklist provided. Within tasks, prompts provided were of an indirect nature such that participants were not told exactly how to complete a particular task. For example, saying 'you need to eat your meal', rather than 'you need to click on the plate of food' (Parso ns et al, 2004)

4.2.3.3 Results

These results are summarised from Neale's AS Interactive internal report (Neale, 2001d). Participants (participants referred to here are those with ASDs) were very comfortable with the set-up and experienced few difficulties in understanding the demands of the task. Even participants who had never used a joystick before, found navigation quite easy after practice during the training sessions. It was particularly noticeable that participants were focused and attentive and seemed very interested in, and happy with, computer-based tasks. All participants performed well on the matching task included in the training environment which suggests that this group of children with ASDs can search for objects, inhibit responding to incorrect 'unwanted' items, and match a sequence of objects in a VE, to a sequence of objects presented in the 'real world'Their performance in the City Cafe was equally impressive. They seemed to understand the metaphors used in the VE very easily and were comfortable with the use of the joystick and the mouse. They listened to the questions asked by the computer and answered appropriately. Only one participant did not complete the tasks in the order specified by the experimenter, the rest seemed to find the instructions and tasks easy to follow. They also seemed to enjoy their use of the equipment, with many stating their enjoyment explicitly

4.2.4 Teacher Workshop

A teacher workshop was held where over 30 teachers and classroom assistants reviewed and commented on existing training VEs developed by VIRART, the Virtual City café, supermarket, house and bus for teaching life skills to people with learning disabilities (Brown et al, 1999) and HEAVE, a factory danger awareness program (Cobb and Brown, 1997). After using this range of training environments, the teachers filled in questionnaires that enquired about the social skills that they currently teach, and the types of skills that they thought may be suited to learning using VEs. They also commented on some important aspects of how these skills should be presented to the user and noted any possible barriers to use. The main social skills identified as important to teachers and suitable to be represented in VEs could be collected into three main groups, personal and social space, perspective taking, and problem solving/dealing with the unexpected. The teachers also specified where these skills should be taught to make them most effective for preparing for employment. Locations suggested included the café, bar, bus, college, and work. It was interesting to note that many of the teachers specified that many problems with social interaction in the workplace happen during the unstructured part of the day, such as the lunch-break. Some features key to the design and presentation of these skills were highlighted: the real world should be represented, scenarios should be presented in a flexible manner, and appropriate and inappropriate decision making should be facilitated. Some possible barriers were identified, and these included problems of use, problems of generalisation to the real world and problems of representing ' the unexpected' (Neale, 2001b).

4.2.5 Requirements Overview

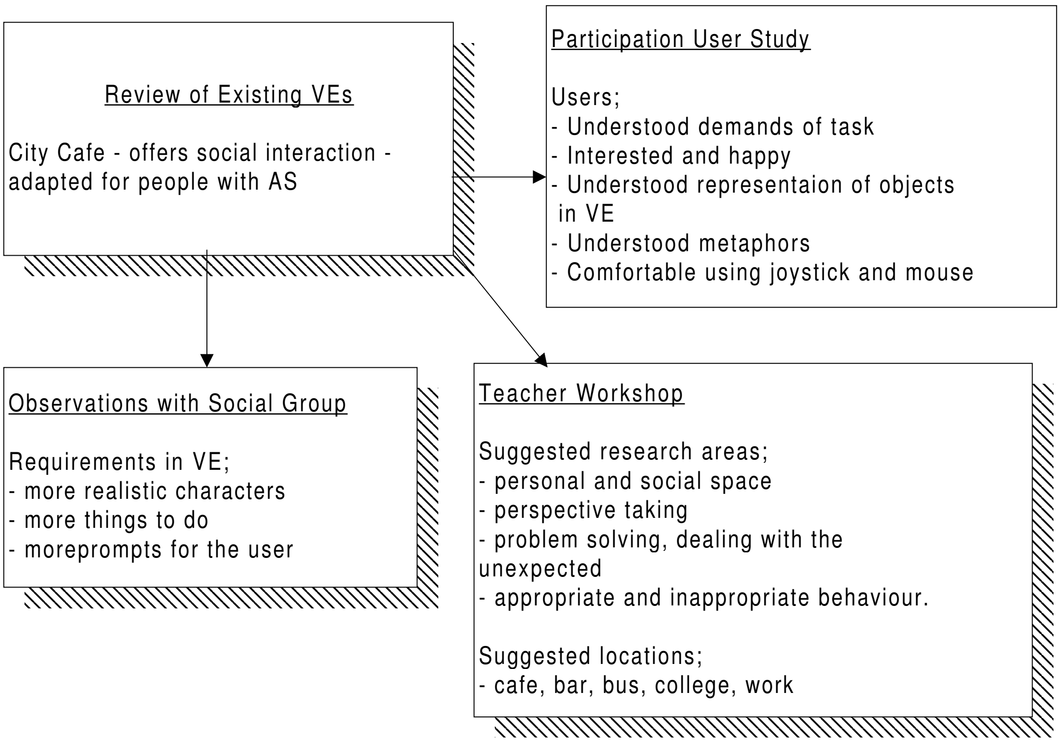


Figure 4-5: Identification of Requirements

Figure 4-5 summarises the main findings of the identification of requirements section. The *Participation User Study* found that people with AS could use a VE such as the City Café to learn. The *Observations* and *Teacher Workshop* highlighted issues to be considered when developing the learning VEs.

4.3 SVE Design Specification

As discussed in section 4.2.4, the café was seen as an appropriate environment to represent key aspects of social skills critical for people with AS in coping with the unstructured parts of their working day. As a result of a process of discussion, brainstorming and exchange of expertise between members of the multidisciplinary research team (see 3.7.2), an initial list of eight scenarios relating to social skills learning within a virtual café was suggested;

- What happens if you bump into people - what their reaction is to this?
- What do you do if there is no space at the bar?
- What do you do if there is no barman?
- What do you do if there are no available seats at the tables?
- What do you do if you are waiting at your table and nobody appears to take your order?
- What do you do if the only seat available is next to someone you don' t know?
- What do you do if they do not have the drink that you want?
- What do you do if there is a table, but no seats, but there are seats at the other tables around you?

It was decided by the other members of the AS project team the project should develop a scenario based on finding somewhere to sit in a café when there were only a few empty seats available. This represented a task similar to a real life situation familiar to the target user group. The real café that they go to requires them to queue for food before sitting down, as the cafe does not take orders from the tables. There was no need to accommodate anything to do with the bar as the user group were under 18yrs of age. Bumping into people was not a priority due to problems users might have in navigating around a VE, while this idea prompted the psychology members of the team to investigate further a user with AS's perception of personal space (see Parsons, 2001). Time constraints meant also that the scenario where the user could not get the drink they wanted was not prioritised, though this issue is raised again later and is dealt with in sections 6.5.4 and 7.2.3. As the VE was intended to support social rather than procedural task-based activity, 3D models were used as the basis for brainstorm and discussion of the design specification (see Figure 4-6). This process defined use of the 3D VE space and activities to be performed by the user. Hand-drawn picture storyboards were then generated to illustrate what should happen in the VE (see Figure 4-7).

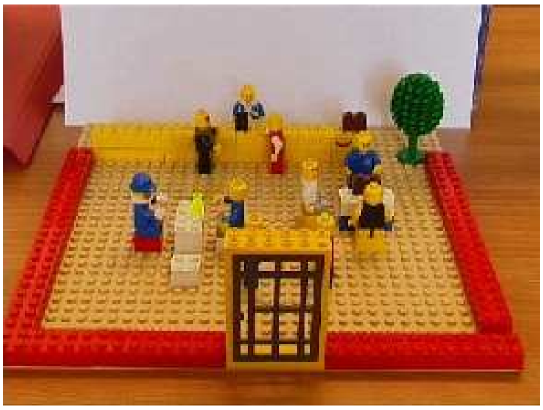


Figure 4-6 3D model of the Social Skills Café built with Lego™ bricks. (Neale, 2001)

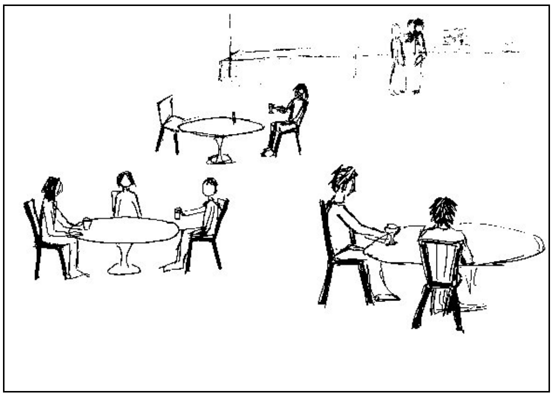


Figure 4-7 Hand drawn storyboards (Neale, 2001)

The research group brainstormed the different ways in which the user could be motivated to sit at the table and the types of interaction they could be expected to perform. It was decided to make the user have a tray of food so that they needed to find a place to put their tray down. This could involve a number of different options including whether there was a free table or whether they had to sit beside someone and if they knew this person. This would also meet the aim suggested in section 4.2.4 to deal with personal and social space. Detailed storyboards were then derived from this brainstorming session, examples of which can be seen in Appendix. A.

Development of the learning SVE could now begin. An iterative process as laid out in section 3.8 was followed which allowed early prototypes to be reviewed by teachers and users and be redesigned accordingly in a short space of time before a more formal evaluation can take place. Prototypes would initially have the physical environment of the VE built with the key learning task programmed along with a basic interface, which would allow interaction with and control of the environment. This allows the key elements of the VE (Prototype 1) to be assessed before the learning task and interface are refined in more detail to hopefully approach a more complete version of the program (Prototype 2).

4.4 SVE Prototype 1

4.4.1 Development

The initial prototype was developed based on the principle aim of the learning scenarios developed in the storyboards; to find a place to sit down in the café. Only part of the scenario was developed to assess initial reaction to the interface and types of interaction within the VE before further scenarios were developed. It also allowed for an initial appraisal of the technical requirements of the program, getting particular programming sequences to work being the priority at this stage, rather than on the usability. Therefore, it would be expected that there would be a lot of negative comments when this prototype was first evaluated.

The prototype contains a panel at the bottom of the screen which is the 2D interface to the VE (see Figure 4-8). This panel was designed by the author in collaboration with the human factors members of the project team. From Table 2-1 in section 2.9, the interface to the VE should use language and symbols familiar to the user on a plain, consistent background and have this feedback given audibly as well. The feedback is not given by a virtual character as used by some intelligent agents (see 2.7.2) as, if it is not a recognizable person to the user, then they might not believe what they have to say. As mentioned earlier, the priority at this stage was to get a working prototype and so icons, text and audio were not thoroughly checked. The interface panel contains feedback information in text form as well as buttons the user can use to interact with the environment. A speaker icon familiar to Windows applications is placed to the right of the text box, but with the same background colour to show they are related. Another speaker icon with a repeat loop on it was added and this is meant to be used to hear the overall objective, helping the user understand what their actions are meant to achieve. The speech bubble icon is there for the user to use when they wish to speak to another person in the VE.

Figure 4-8 Café Prototype 1 Interface

The layout of the café prototype consists of a number of tables spaciously laid out, some full, some with empty seats. Plain colours and an avoidance of unnecessary textures were used as stipulated by teachers. The user starts with a tray of food at the counter and has to navigate their way to a table with an empty seat. Once close enough they are able to either click on the table to sit down or click on the speech bubble to ask a question. If the user just sits down, they are told that someone is already sitting there, so that they can learn that they have to ask permission to sit down. If the user clicks on the speech bubble, then a bigger speech bubble (being consistent, see section 2.9) appears, containing three questions, two of which are appropriate to the task, one which is not (see 4.2.4). If an inappropriate question is asked then feedback is given to the user to try something else (see 4.2.2 and Table 2-1 in section 2.9), but if they chose an appropriate question they can then sit at the table.

4.4.2 Observation Study

An observation-based field study was carried out with four members of one of the AS social groups who had participated in earlier evaluations of existing single user VEs. The aim of the study was to examine behaviours of a group of representative users interacting with the VE and to obtain their opinions about the program. Their group facilitator also attended and sat with each individual as they used the program. A range of evaluation methods were used such as contextual interviews and video recordings, of which more details can be obtained in Neale (2001e). A summary of the data obtained from this evaluation can be seen in Appendix B.

The research group felt that many problems arose due to the user not knowing how to interact with the VE rather than an inability to do so. The participants, as well as performing tasks incorrectly, did not make use of some of the features that could have helped them, such as the speaker icons to re-hear instructions. It was proposed that a training environment would be developed to show the user how to use features of the interface and then allow them to practise these features before using the learning scenario described in section 4.5.5. The research group also decided to implement a suggestion from the social group facilitator, that a number of difficulty levels should be used based on the difficulty of social interaction ranging from plenty of empty tables to there being none at all. It was also decided that there should be some acknowledgement of the user completing the task successfully to give the user encouragement (as fitting guidelines in section 2.9). As can be seen, many suggestions were already noted in guidelines from the literature, but had not been implemented in this early prototype. The next iteration of the prototype would address more of these issues.

4.5 SVE Prototype 2

4.5.1 Interface

The interface to the updated prototype included changes to the icons based on the observations discussed in section 4.4.2. The speaker icon was replaced with an ear icon and a question mark icon for hearing the overall task. These were thought to be good alternative symbols that represented listening (hearing current instructions) and help (finding out overall task). On this updated prototype there is also another panel at the top of the screen, which is used to select the level of difficulty for the scenario, ranging from easy (green) when all tables are empty to difficult (red) when all tables have people sitting at them. The user selects which level they wish to try by clicking on the relevant colour panel. (see Figure 4-9)

Figure 4-9 Café Prototype 2 Interface

4.5.2 VE Layout

The VE is a café environment with a food counter and bar area and uses subtle colour throughout so as not to overload the senses. The open floor area contains 6 tables, spaciously separated to allow ease of navigation between them and with invisible barriers placed next to the walls to prevent the users viewpoint going into the walls or from accidentally leaving the environment (see Figure 4-10). The tables can either be all empty for the easy level or in various stages of occupation as the levels get harder with some full tables and others with empty seats. The people at the tables are as much as possible a varied mix of genders, ethnicity and looks to give a more realistic feel to the program. Different table and chair layouts were used to generalise and show that there could be many different styles of furniture in places the user might visit. In the harder level there are people standing on the floor to help communicate the busy feel of the place as well as to cause an obstacle of sorts to the user. The user's viewpoint in the VE has a tray of food in front of them, to motivate the user in completing their task, as well as offer a visual cue to their orientation within the environment. To sit down, the user can click on the table or chairs of the table they wish to sit at and can click on the floor whilst seated to stand back up again.

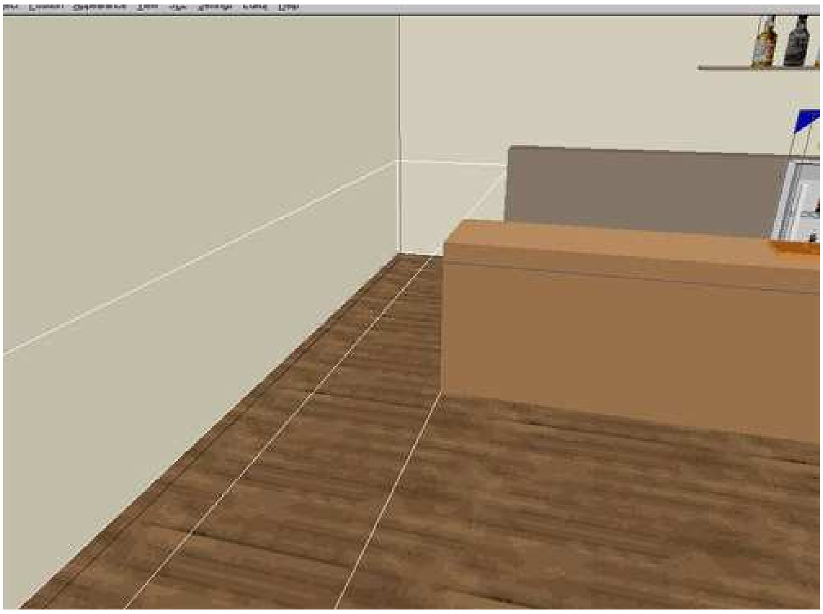


Figure 4-10 Highlighted Invisible Barrier

4.5.3 Scenario

The overall task for the user is to find a place to sit down with their tray of food. The user starts the scenario at the food counter (getting and paying for their food was not seen as part of the learning goals at this stage) with their tray of food facing towards the tables. What they do next will depend on the level they are on;

Easy Level: All the tables are empty and so the user can sit anywhere they like. When the user has approached close enough to a table they are informed of the fact and can then either sit down or move to another table.

Medium Level: All the tables have at least one person sitting at them except one, which is ideally where the user should try and sit. If they choose to try and sit at a table with people sitting at then a number of possible outcomes are played out. When the user is close enough to a table with an empty seat, their viewpoint is auto rotated towards the centre of that table to get a clear view of everyone there and the viewpoint is temporarily made static so they can't accidentally move away until they make a definite decision to do so. The user is told that they do not know the people at the table and are asked what they wish to do. At this point they could just click on the table or chairs and sit down without asking, but if they do this then the user is told someone is already sitting there to discourage them from this course of action. If they click on the speech bubble to ask a question then a dialogue box appears with a larger speech bubble, containing three questions, two of which are appropriate, the other inappropriate to the task. If the inappropriate question is selected then the user will be informed of this and asked to try something else. If an appropriate question is asked then the response given will be dependent on whether the user had asked a question or not before. If it is the first time the user has asked an appropriate question then they will always be given a negative response. This is so the user does not think that, by doing something appropriate, they shall always be rewarded by completing the task. If the user has been told that there are no seats available at a table then they will not be able to interact with that table again if they approach it at a later stage. If the user is told that there is an available seat then they can either sit at the table or move away, though they will be informed that they are moving away from an available seat.

Harder Level: This is the same as the medium level described above except that there are people sitting at all the tables and therefore must interact with them if they are going to be able to sit down.

4.5.4 Scaffolding

The scaffolding in the prototype includes the auto rotations and fixed viewpoints as described in section 4.5.3 above. The user is also unable to interact with the table groups unless they are close enough to them and if they try to click on tables when too far away then the user is told to move closer. Scaffolding in terms of help to the user comes in the form of instructions given to the user if they perform an action which prevents them from completing their task, such as moving away from a table that has available seats and preventing the user from interacting with tables which have no empty or available seats. Scaffolding in the learning process comes in the form of the user always experiencing a negative response and from not being able to just sit down at a table without asking the people there first.

4.5.5 Interface and Metaphor Training VE

A training VE (see Figure 4-11) was created with the intent of teaching the user how to use the interface and metaphors encountered in the updated café prototype. The user can select from three levels of difficulty in the training VEs which are;

Easy – The user just observes while the program shows how to use the interface by highlighting the interactive elements whilst the scenario is run through with a running audio commentary.

Medium – The program runs through the various options presented in the easy level of training, but this time asks the user to interact with specific elements of the program while highlighting where to click. The level then pauses until the user makes the correct interaction.

Hard – The program asks the user to interact with specific elements while NOT highlighting what to click. Feedback is given as to whether user carries out each stage correctly and again the program does not proceed to the next element to learn until a correct interaction has been performed.

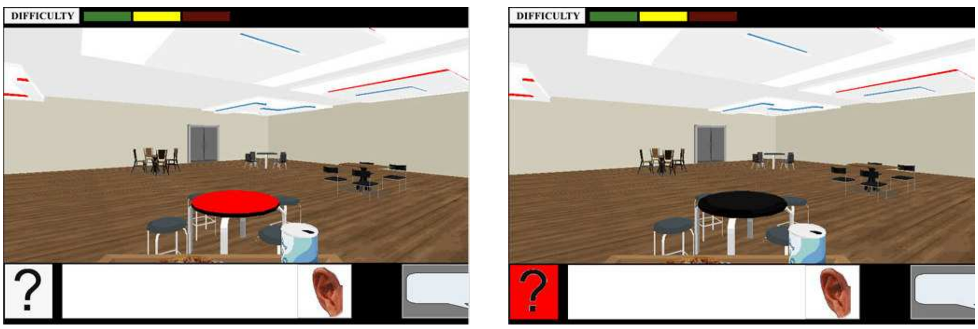


Figure 4-11 Training Environment 3 showing highlighted interactions.

The user selects which level of training they wish to use by clicking on a bar at the top of the screen which is also how they would select different levels in the actual café VE so this again forms part of the overall training for the user. The user would be expected to reach and complete the hard level of training before being able to use the café social skills VE.

4.6 Prototype 2 Evaluation Studies

The evaluations described in this section were conducted by different users in different contexts of use, as shown in Table 4-1.

USE	CONTEXT
Individual User	Adult Social Group (1)
	School IT room (2)
Group Training	16+ Class (3)

Table 4-1: Prototype Evaluation Study – Use and Context

4.6.1 Social Group Observations (1)

The updated prototype and training environment were reviewed using eight people from the Social Group, including four participants that evaluated the initial prototype in section 4.3. The VE was run on a laptop and was controlled with a joystick and mouse as before. The users again had their social group facilitator sit with them during the review and the sessions were video taped. A series of questions were drawn up to ask the user after they had used the program, though these were just a guide and could be adapted by the reviewer depending on how the user coped with the environment. Data collected from this review can be seen in Appendix C.

The main findings can be summarized as follows:

Training Environment:

- Too wordy and complex
- Too long and not always completed
- No option to rehear instructions
- Not obvious which level is which
- Not utilised enough
- Could encourage user to try out interactions in café VE in order learnt in training VE.

Café VE:

- Some users more capable than others in using interaction metaphors
- Generally few problems with task
- Users usually require help from facilitator
- Some users had problems using both a joystick and mouse
- Not difficult enough for some users
- Confusion over icons

Recommendations:

- Have training inbuilt into actual learning VE
- Have numbered levels on interface
- Have a busy/noisy level added

4.6.2 Rosehill School Observations (2)

Although the single user café VE had been developed with a user centred design approach, it had not been tested where it was expected to be used eventually, i.e. in a school. This would enable a more realistic evaluation of how the program was developing as well as take into consideration how the software would be used and how it could fit into existing teaching strategies or whether new ones would need to be adopted. Observations took place at Rosehill School in Nottingham with the 16+ class either with individuals in the computer room or in group sessions in the classroom.

The first session was held in the computer room at the school with the student sitting in front of the PC monitor, controlling the VE with joystick and mouse, while their teacher sat alongside them to provide guidance if required. Four students used the VE, three with Higher Functioning Autism (HFA)/AS and another with more severe learning disabilities. Normally students were taught not to sit beside people they did not know, but no strategies had been discussed regarding what do to if there was no alternative, so the students had to discuss with their teacher what the most appropriate strategy would be whilst using the VE. It was observed that some students struggled with the more difficult levels and that it would be a good idea to gradually introduce them to tasks such as asking a question. It was felt that if the program gave a verbal prompt in certain places it could scaffold the activity.

The second session took place one week later and the same users as in the first were used. Again the sessions were in the computer room, but this time the training VE (see 4.5.5) was used as well. However, the outcomes from this session were markedly different. The three students with HFA/AS had all learned the appropriate responses in session 1 in order to complete the task. In this session, repeated behaviours were displayed such as approaching the tables in the same order, knowing exactly where the empty table was and selecting the same questions. In the hard level, many users did not even bother to look around the room to find an empty table as they had remembered from the previous week that there wasn't one on this level. Some students after using the training environment also tried to interact with the café environment by pressing icons or clicking with the mouse in the same order they were presented with them in the training environment. The observations here showed that students were able to memorise quite easily the 'correct' answers to a problem, but this was done as rote and therefore highlighted the need for flexibility within the VE so that the user had to think more carefully about their actions. This requires more randomness to be applied to the VE, although the structure must remain which guides the user in trying different options. It was recommended that the appearance of the café should be randomised with different looking people in it and positioning tables, especially empty ones, in different parts of the café, each time the user used the program, thus forcing the user to have a look around. Also, having a different selection of questions to ask, with the positions of the appropriate ones altered would also require the user to have to think more carefully about their choice.

4.6.3 Using VEs in a Group -Observations (3)

Observations with students at Rosehill School in Nottingham continued with the 16+ exploring how the VEs might be used in a group situation as this would be a likely teaching strategy adopted by teachers. The VEs were installed on a Pentium 2, 800MHz, 64Mb Ram laptop and were projected onto a 4x4 foot screen which was placed in the corner of the 16+ common room, where teachers would normally use flip charts etc when having group discussions and the laptop was placed on a low coffee table in the centre of the seating area, which consisted of a series of sofas around it. The user would sit in front of the laptop as this is where the input devices, joystick and mouse, were connected, though the laptop screen was disabled so that everyone was looking at the projection screen. This was especially useful when the teacher was pointing something out. The rest of the group were sat round on the sofas and chairs watching the big screen (see Figure 4-12). The benefit of using a big screen for a group session is similar to that of a single user in front of a monitor in that the concentration of the user is limited to the bounds of the screen. This small area of focus explains why higher input levels can be tolerated than from other sources (National Autistic Society, 2001).

Figure 4-12: Group Session 1 Rosehill School

The teacher started the session by explaining to the students what was going to happen, what they were expected to do and why they were going to discuss the issues raised. The teacher initially took control of the VE, asking the students for instructions on what to do, before letting one of the students have a go. Although some students were more proficient than others, the difficulty levels were gone through in order of easiest to hardest. This allowed everyone to see the progression in the scenarios and discuss what was happening as a group, helping those less proficient to get as much from the experience as possible. Some students would be more engaged than others, partly due to the level of challenge and partly due to their mood at the time, which would vary from session to session. Nobody was forced to have a go and many were quite happy to just sit and watch, though it was hoped that in future sessions they would eventually be more confident to have a go themselves. After someone finished their turn they chose the next person to have a go, though again, they did not have to accept the invitation.

From the sessions it appeared that the class discussions around the interaction with the VE adds a lot of richness and meaning to what is happening in the scenario, with the teachers able to explain things a bit more clearly (for example when the man in the VE says that "someone is sitting there" when referring to a seat at his table, the teacher can explain what he means as nobody is literally sitting there. A major problem however was that the individual controlling the VE would sometimes want to work quickly through the tasks, leaving little time for the rest of the group to discuss issues. The teachers would try to intervene to allow the rest of the group to be involved, but the student in control could often just carry on regardless and not be influenced by the group discussion that may be taking place around their actions. The teachers commented that it was difficult for them to reflect with the group properly on what was happening with so much going on so quickly and thought that they might run a follow up session with the teacher using the VE to illustrate some concepts followed by discussions and worksheets. It was also apparent that there should be more to do in the café as students were getting quite familiar with the task of finding a seat. Teachers recommended that the queuing for food scenario that had been initially left out should be added. From these sessions recommendations were:

- That a pause button should be incorporated into the café which could be controlled by the teacher alone and allow them to 'freeze' the VE at any time to allow discussion to take place about what had just occurred on the screen.

- Having a 'what is the other person thinking' button would enable the user to see other peoples perspectives on any inappropriate behaviour they had exhibited which teachers find difficult to convey.

4.7 Discussion and Conclusions

Even though it has been suggested that VEs could be beneficial for teaching people with autism, there has been little research into actual VE applications. The research described in this chapter looked to address this by developing social skills training VEs that can be used in schools. A user centred design approach was used, involving schools, teachers, students with AS and autism experts. They all helped inform the design of the application, starting with storyboards to help develop an initial prototype. The initial prototypes and training environments tested some of the features that will be used such as interaction metaphors and navigation and this suggested that VEs could be used by students at school. The VEs were developed using Superscape VRT, but issues relating to its use can be transferred to other single user platforms.

The development of the VEs followed a design/develop/evaluate/redesign iterative process and a number of iterative steps are desirable early on as there will inevitably be a lot of initial problems and changes to be made. Prototypes of the VE can allow quick assessment by users into specific elements of the program and is much easier to visualise where the program is trying to head. Early observations of the prototype being used in context is also desirable as this will highlight a whole set of other issues that would not be discovered in lab testing or heuristic evaluation. Observations discussed in this chapter have shown that there needs to be a balance between the freedom of choice that VEs offer and structure to ensure that appropriate learning takes place.

Observation results from the first phase of development help inform design changes for the second phase which is to produce more completed environments which contain the majority of learning goals in a usable interface. One of the most fundamental changes to be made in phase 2 is to incorporate more scaffolding into the learning scenarios instead of having a training environment used beforehand. Students with autism are very good at remembering rules, even if they don't know why they are learning them (DeCorte, 1993) and this is why when it comes to actually learning that a more constructivist rather than instructional based approach is better if any kind of generalisation is to take place. So for instance, if the user approaches a table and doesn't either click on it to sit down or ask someone a question then the program should inform the user after a series of incorrect attempts what options they have and how to carry them out. This may start out as just a verbal instruction, but highlighted icons/objects could then come into play if they still required help.

The prototype, by its nature, did not have much for the user to do and this criticism was observed in the evaluations. As well as expanding the café scenario to make it more difficult and to include other learning goals such as queuing, another scenario needs to be developed to incorporate the same task, finding a seat, this time on a bus (one of the contexts suggested by teachers in 4.2.4). Presenting the same task in different scenarios allows us to examine transfer of learning from one context to another, which can be problematic for users with autism. The development of the bus can take on board the issues discovered in the café prototype and so in theory have a head start and be further down the iterative process than it otherwise would. Another major finding in the observation trials was the need for randomness and more choice, specifically in appearance and how the task is completed. Overall recommendations for the next stage of development taken from these observations or not completed from original guidelines/research findings (in Chapters 2 and 3) can be summarised in Table 4-2, where observations 1, 2 and 3 relate to the evaluations in section 4.6.

Recommendations:

Design Aspect	Method	Recommendation
Training / Scaffolding	Observation 1	Have training of metaphors inbuilt into learning scenarios.
Interface / Scaffolding	Lit Review	Have dynamic interface
Interface	Observation 1	Have numbered levels
Scenarios	Observation 1	Have a busy/noisy level to make more difficult
Scenarios	Observation 3	Have a queuing scenario.
Randomness / Layout	Observation 2	Give café a random appearance in places which affect learning outcome, such as position of empty table.
Randomness / Interface	Observation 2	Offer more questions for user to ask in a random manner with position of appropriate questions altered.
Interface	Observation 3	Have pause button
Scenario / Interface	Observation 3/ Teacher Workshop	Have 'what is other person thinking' option.
Scaffolding	Observation 2/ City Café Observation	Give verbal prompts to help user complete task.

Table 4-2: Prototype Review - Design Recommendations

4.8 Summary

This chapter has described how the initial design of the café scenario was informed and how the subsequent prototype VE was developed. It describes the iterative process of design/develop/evaluate/redesign through a number of stages, highlighting the importance of carrying out user trials in the environment the application is going to be eventually used. Observations showed that all training should be included into the scaffolding within the actual learning environment an that the environment should be flexible and offer challenges to suit vary levels of skill, knowledge and competence.

Chapter 5. 2nd Phase Development of VEs

5.1 Introduction

The first phase of development discussed in Chapter 4 highlighted the changes that were required to develop VEs suitable for users with ASDs. Various recommendations regarding the design of the interface and content of the café VE were made and these were to be implemented in the next phase of development, which would see the learning scenarios being expanded to include a bus VE.

This chapter describes that next phase of development (see Figure 5-1) by initially looking at how the café VE was adapted, based on recommendations discussed in section 4.7. Design of the new bus VE scenario could also take these recommendations into account. The additional learning scenarios added to the café VE are described, including how the training for this VE, previously external to the program, was incorporated within the learning scenarios themselves. Random features such as décor and position of tables are also described to show how the VEs could be adapted to prevent users with autism from learning by rote rather than from memorising previous interactions.

The bus VE development takes on the same design/evaluate/redesign iterative cycle as the café VE did in phase 1 and this chapter describes a number of stages of this process. This includes a description of the different levels of difficulty, the scaffolding required within the VE, including inbuilt training, to aid learning and make the application usable both from the user's and teacher's point of view and in a practical setting. The development of the bus VE is described up to the point that it is on a level footing with the café VE with both programs then studied in the same observation sessions. These observations were to help make finishing touches to both programs before they could be released as beta versions to schools and organisations for larger scale analysis and formal evaluation. Screenshots of the finished beta programs are shown as well as an overview of the structure of the code within them before finally discussing the outcomes from this phase of work and what is required to take the research forward to reach the goal of having usable learning software for people with AS that would actually be adopted by schools.

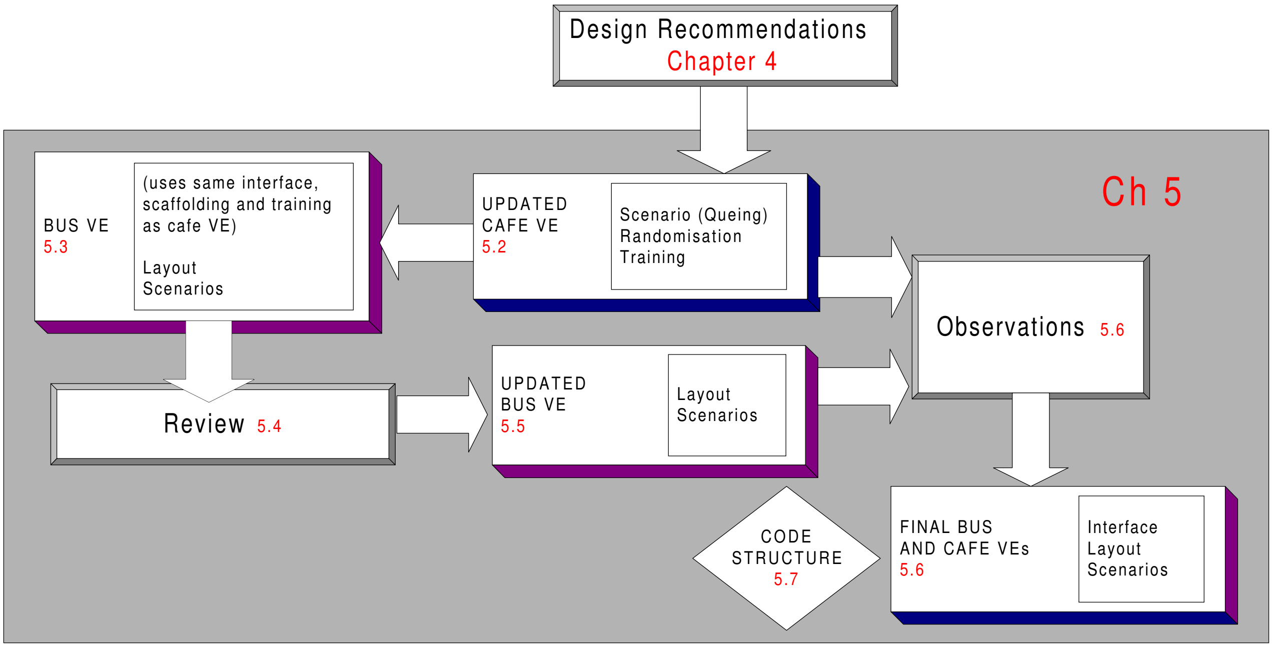


Figure 5-1: Chapter 5 Overview

5.2 Updated Café Scenario

An updated version of the café VE was now made based on recommendations from observations, listed in discussion section 4.7 and in section 4.6.3.

5.2.1 Queuing Task

A queuing task was added to the café scenario to help set the context of the overall task by making the user get some food before sitting down. Queuing is an important issue for people with autism and is taught regularly in the class as well as there being multimedia applications teaching the subject such as Johnny's World from Leeds Metropolitan University (http://www.lmu.ac.uk/ies/comp/staff/dmoore). In line with there being varying levels of difficulty in the finding seat task, the queuing task represented different levels of difficulty by having no queue in the easy level (nobody sitting at seats so unlikely to be queuing anyway), a small queue for a partly busy café and a long queue for the harder level when the café is really busy.

Figure 5-2: Bounding cubes and queue.

The part of the café where the queue is can be seen in Figure 5-2. The avatars are given these initial positions and are made visible or invisible depending on the length of the queue. Invisible bounding boxes (also shown in Figure 5-2) around section lengths of the queue are used by the program to determine whether a user has 'jumped the queue' or joined at the back. On the easy level where there is no queue, the user just has to navigate up to the counter to be served their food. If the user pushes to the very front of the queue, where the cashier is at then they are given the benefit of the doubt and told they have to get some food first before they can pay for it. If the user pushes anywhere inside the queue, then the user will be told by someone working in the café that they have to join the end of the queue. A thought bubble will then appear on the interface (Figure 5-3) and the user is asked to click on it to find out what the person next to them is thinking. This was done in an attempt to give the user an understanding of why their action was inappropriate, especially as people might tell them off for pushing in front, but not really explain why this would upset them, so this can be 'thought aloud' through the metaphor of the thought bubble (see also 4.2.4 and Table 4-2).

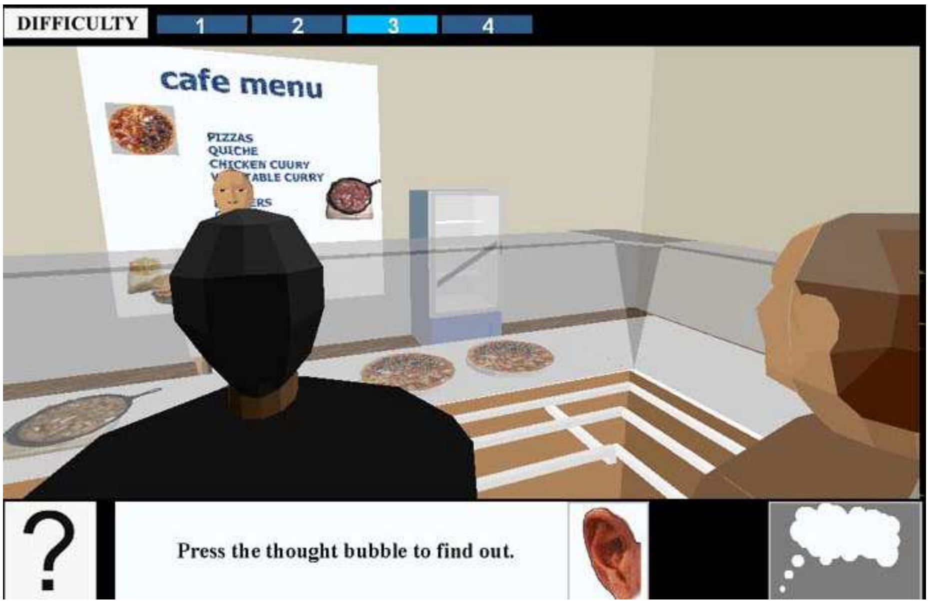


Figure 5-3: Thought Bubble for Queue Jumping

The thought bubble icon appears in the same section of screen as the speech bubble does, but only appears when it can be used, which is also the case for the speech bubble icon. This conforms with the dynamic interface research discussed in 2.6.7. The program detects a mouse click event in the area where the icon goes and then starts the relevant sequence in the program depending on what texture is shown. In this case the queue jump scenario is started, the code for which can be seen in Appendix D. When the user leaves the bounding cube around the queue, the program effectively resets itself and so if the user pushes in again the whole sequence is repeated, otherwise the user joins the end of the queue, entering the invisible cube there, triggering the next sequence of events which in this case is the user getting their food.

The user is then automatically moved towards the food counter to order their food. They are moved automatically because movement here is not seen as a learning goal, there is no need to explore, it is just a case of the user's ability to control their character and as some people's ability in controlling the joystick or movement of their character might not be as good as others, the rest of the learning scenario should not be delayed by this (see Table 2-1). At the counter the user is given a choice of food from a menu which is shown in both pictorial and text format (Figure 5-4). The menu is displayed as a set of radio buttons, which means that only one choice can be selected at any one time. A default choice is set up beforehand in case the user accidentally forgets to select anything and once the user is happy with their choice, clicks the ‘ok’ button, with the food that they chose appearing on their tray. The tray is contained within a group that is attached to the user’s viewpoint and within that group are objects with textures representing all the various food choices available, with only the chosen food object being made visible. The user is then again automatically moved slightly along to the cashier where they have to pay for their food.

Figure 5-4: Food Menu

Paying for their food in terms of giving the right amount of money over was not seen as part of the learning goals on this occasion and indeed has been covered in other learning VEs developed by VIRART, so on this occasion it was just a case of showing that the process of paying had to take place. Therefore a £ icon appears on the interface and when the user clicks on this, money textures appear on the counter to show the food has been paid for (see Figure 5-5). While the user is paying for their food and indeed when they were choosing from the menu, their viewpoint was made stationary. They could still rotate their viewpoint to look around, but forward and lateral movement was restricted so that the user did not accidentally move away. Once the user has paid for their food they then begin the café prototype sequence, where they then have to find a seat to sit down.

Figure 5-5: Paying for food in café.

5.2.2 Random and Extra Features

A new level was added to the café which was exactly the same as the original hard level, but this time there is a sound effect playing to simulate the kind of background noise you would hear in a café and some walking avatars were added as well. This was in response for a need for the environments to gradually increase in realism with more and more stimuli being offered which could confuse or unsettle the user (see section 2.9). In addition, this new harder level would also include a response telling them that there were no seats available at the table when they first asked an appropriate question. This was to show the user that in real life, just because they show appropriate behaviour does not mean they will get what they want. The middle levels, 2 and 3 would always have a seat available when the user asks an appropriate question, so as not to discourage the user early on. The coloured panels representing level of difficulty at the top were replaced with more obvious numbered ones. The heads of the avatars facing within 180 degrees of the user would have their heads rotated to face the user when they approached the table as a visual feedback that they were interacting with the people there.

```
short  flag=0;
long   floor, newpos, oldpos;
objnum tabgp[7], gpmarker[7];

resume (3, 3);
tabgp[1]='  tablegroup1'  ;
tabgp[2]='  tablegroup2'  ;
tabgp[3]='  tablegroup3'  ;
tabgp[4]='  tablegroup4'  ;
tabgp[5]='  tablegroup5'  ;
tabgp[6]='  tablegroup2[112]'  ;
gpmarker[1]='  marker1'  ;
gpmarker[2]='  marker2'  ;
gpmarker[3]='  marker3'  ;
gpmarker[4]='  marker4'  ;
gpmarker[5]='  marker5'  ;
gpmarker[6]='  marker6'  ;
/* randomly sort decor and arrangement of cafe */
if (flag==0)
{
  floor=random (4);
  timgref ('  wall[369]'  , 1)=floor+1;
  flag=1;
}
if (flag==1)
{
  newpos=1;
  while (newpos<=6)
  {
/* randomly give table and marker positions */
    oldpos=newpos+floor;
    if (oldpos>6)
      oldpos=oldpos-6;
    xpos (tabgp[newpos])=ixpos (tabgp[oldpos]);
    xpos (gpmarker[newpos])=ixpos (tabgp[oldpos])+xsize
        (tabgp[newpos])/2;
    ypos (tabgp[newpos])=iypos (tabgp[oldpos]);
    zpos (tabgp[newpos])=izpos (tabgp[oldpos]);
    zpos (gpmarker[newpos])=izpos (tabgp[oldpos])+zsize
        (tabgp[newpos])/2;
    newpos=newpos+1;
  }
  flag=2;
}
```

Figure 5-6: Code for determining closeness of user to table

As stated in section 4.6.2, there needs to be elements of randomness built into the program so that the user has to think more carefully about their actions and not just learn a sequence by rote. Therefore the positions of the tables were altered every time the VE is reset, though not when a different level was chosen. The code listed in Figure 5-6 shows arrays for the groups of tables and chairs and for the markers, which were used to help position these groups and determine a user's closeness to the table. (see Figure 5-7). The variable *floor* which is used to determine which floor texture is displayed is also used to determine where the tables are positioned. Basically every table is given one of the 6 positions, but in sequence, e.g. tables 1-6 given positions 3,4,5,6,1,2 dependent on the random variable. This was the quickest way to program this feature, though of course it means there is still a pattern to the way the tables are laid out, albeit less obvious than a non-varied layout.

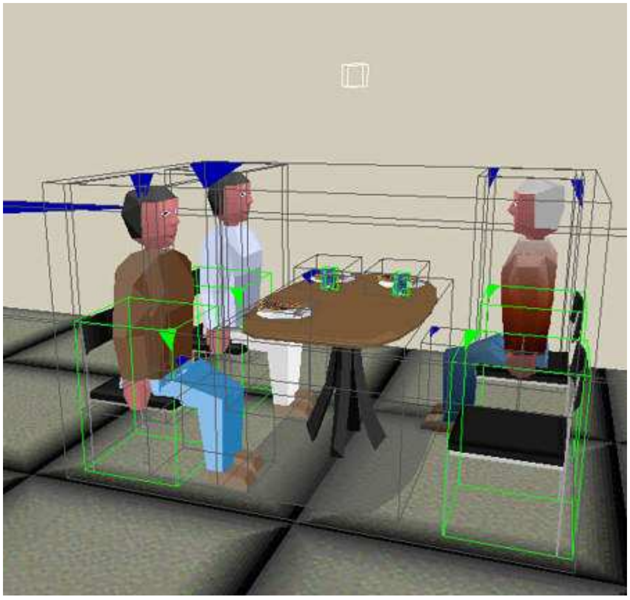


Figure 5-7: Table group with highlighted 'marker' object

Another alteration to this program was that a greater variety of option was included in the list of available questions. Instead of there being the one set of three questions, there were now 4 sets of 3 varied questions (2 appropriate, 1 inappropriate to the task), though sometimes the same questions were used in different sets. Apart from the different wording of the questions, the real point was to move around the positions of the appropriate and inappropriate questions for the task.

A random variable was also used to determine what floor texture was used, to again give more variety and not allow the user to become too accustomed to the environment. The position of avatars in the queues also varied so that the user did not just learn to 'stand behind the person with the green jumper'. These changes only occur though when the VE is reset. If a new level was selected then the positions of the tables and chairs and the floor texture remain the same, so that the teacher can test the student on different difficulty levels over the same layout if desired. If the layout was to be altered, then the teacher can reset the whole environment by pressing F12 on the keyboard.

5.2.3 *Inbuilt Training*

The inclusion of training of the interactive metaphors into the actual learning scenarios fits in with the scaffolding of learning discussed in section 2.7, as the help given to the user in *how* to interact with the environment can be coincided with *what* to do in the environment and therefore how to complete the task successfully. It therefore is logical that most of the training and scaffolding will take place in the easy level and then have this scaffolding dismantled as the levels get harder.

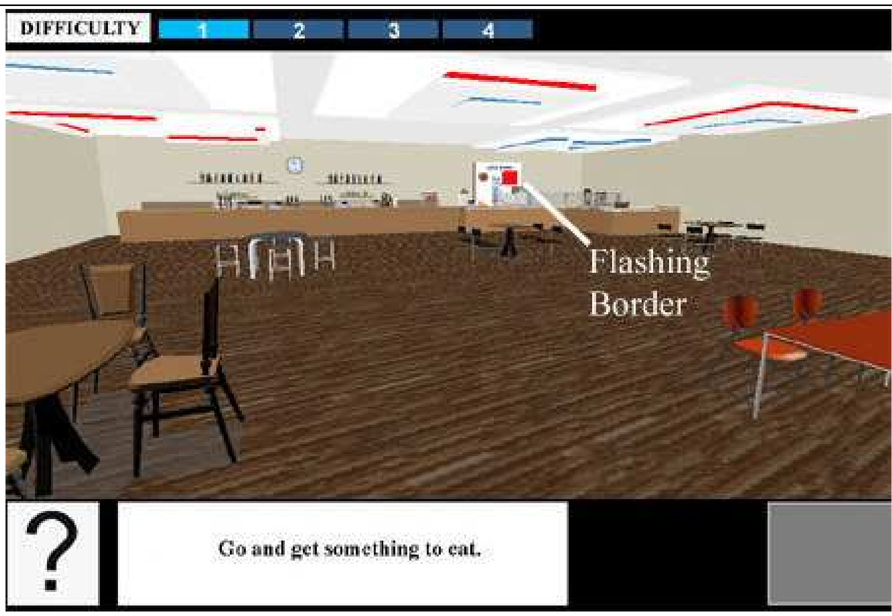


Figure 5-8: Users initial view of café with red panel at food counter.

As in the earlier training VE, the help given to the user here will be in the form of highlighted icons and flashing borders and written and verbal prompts. At the start of each level, the user is first asked to get something to eat. As a cue to help the user know where to go, in Level 1, a small flashing red border is displayed at the food counter (see Figure 5-8). On this level, the £ icon is also highlighted when the user has to pay for their food. When the user approaches a table in Level 1, which will of course be empty, the user is given the choice of sitting at the table or moving away. The metaphor of clicking on the table will be demonstrated by the teacher as it was felt that the users learnt these very easily and it was best to reduce the number of flashing objects (as opposed to icons or directional aids) in the VE as much as possible as this could confuse the user (see Table 2-1).

Marshall (2005) investigated the use of visual cues to aid navigation and interaction within a VE. She formally investigated the use of flashing visual cues, previously used by the author in the Virtual City (Brown, Kerr and Bayon, 1998) project as well as the Virtual Tenancy program (distributed by Pavilion Publishing), and also examined the effect of using different coloured cues, both flashing or just highlighted as well as sound, movement and added photo realism. The red flashing panels were found to be the most effective cue (but not significantly so over other colours with the assumption that these colours stood out in some way from the environment, e.g. using blue panels in a sea environment would be ineffective), though these findings were for people of 'normal' cognitive function. Marshall also found that people still recognised the objects being cued and why they were interacting with them and did not just interact with the cue itself and not pay attention to what it was they were interacting with. While it appears that these cues have been effective in the past with people with learning disabilities, there is a requirement for further investigation into cues for this user group and in particular people with ASDs.

In Level 2 there would be no flashing border to show where the food counter was and no hint what to do at the empty table, but if they approached a table with some people at, they were told they had the choice to ask a question, move away or just sit down. There would then be no hints given in Levels 3 and 4.

5.3 BUS VE

As suggested by teachers in section 4.2.4, another VE that could teach social skills would be a bus. The aim of the bus VE was to provide the user with a similar task to that in the café VE (finding a place to sit down), but set in a different context. This could be used to test for and teach generalisation of social behaviours in different contexts, or at least a realisation that different rules may apply in different contexts. Another series of storyboards were drawn up with the help of teachers, with the following initial levels proposed.

- Empty bus, every seat available.
- Partly filled bus with spare seats beside people, as well as spare double seats.
- All double seats with at least one person in them.

The double seats mentioned above refer to the common situation on buses where seats are grouped in twos at each side of the bus allowing two people to sit beside each other.

The bus VE was developed with a couple of early iterative steps to test out the initial coding of the program with no queue and no people on the bus. This allowed for some debugging of the system and to get the initial structure of the program in place.

To ensure uniformity and allow users to progress onto the bus VE from the café VE with as little trouble as possible, the same interface was used with the levels appearing at the top of the screen and a text box and interactive panel at the bottom. The interface originally had the same colour levels shown at the top with the question mark and ear icon at the bottom as the bus VE was initially constructed before evaluations of the café VE were finished (see Figure 5-1), but was modified to be the same as the updated café (see Figure 5-9). The user navigates around and interacts with the environment in the same manner as to that in the café, with again instructions being given both written and verbally.

Figure 5-9: Evolving Bus VE Interface

5.3.1 Layout

The scene starts with the bus waiting at a bus stop and with its doors open. High buildings are placed around the street to enclose the space with background textures used in the distance to help increase the level of immersion. (See Figure 5-10)

Figure 5-10: Overhead view of bus VE

There are visible as well as invisible barriers along the streets which prevent the user from just wandering off and there are people standing and walking around the pavement. Again there is a queue, which will alter in length depending of the level of difficulty. The bus is a single-decker where the user has to pay the driver and then collect their ticket from the dispenser. On the bus there is a row of 3 seats facing side on to a luggage rack and this row is always full or empty to avoid complications in the tasks. There are then 5 rows of seats, 2 on each side and a single row at the back with at least some people sitting on each row. Invisible barriers were placed along the sides of the aisle next to the seats creating a channel for the users to move in, preventing them from getting stuck between the seats, which happened on some early tests and which caused frustration amongst the users (see Figure 5-11).

Figure 5-11: Invisible Aisle Barriers

Seated avatars had to have their legs 'attached' to the seats which means the legs are rendered on top of the seats. This is due to the fact that the leg and seat objects overlap due to the bounding shape always being a cuboid and this can cause rendering problems (see Figure 5-12). Due to the number of people on board the bus and the fact that each person is made up of a large number of facets, then some clipping has to take place when the user gets on the bus. This means that objects that cannot be seen by the user once they are on the bus, such as the outside of the bus, wheels and other buildings, are made invisible to help the computer processor deal with the objects that are required to be rendered, otherwise people would disappear in front of the users eyes, destroying the illusion of being there. This can depend a lot on the PC being used and continuous checks had to be made to ensure this problem did not occur on the different PCs at the schools and when further objects were added.

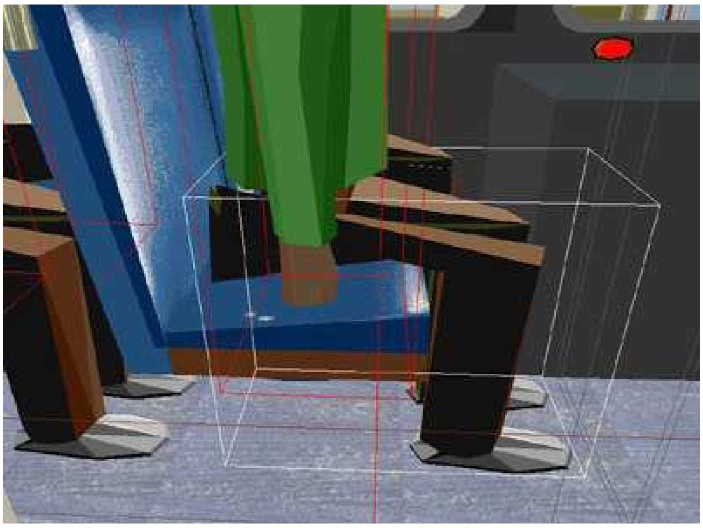


Figure 5-12: Leg bounding cuboid overlapping chair object.

5.3.2 Scenarios

1 – Empty bus with no queue. The user gets on board the bus, and is told to pay for their ticket. The user clicks on the coin slot and coins are seen and heard going in. The user then has to collect their ticket from the dispenser by clicking on it. The viewpoint of the user is then automatically turned to face down the aisle and they are asked to find a place to sit down. As there are no other passengers on the bus, the user can sit down anywhere they like by clicking on a seat, though they are always put on the window seat for ease of programming at this stage

2 – Partly filled bus with empty rows at back and available seats next to people at front of bus with no queue outside. The user gets on bus as before, but now when they have to get a seat, they should try and sit on the empty rows, but can if they choose, sit beside someone. If the user sits beside someone then a thought bubble appears on the interface just as in the café environment, and the user is asked to click on it to see what the person next to them is thinking (the person is uncomfortable that someone sat next to them when there were empty seats available)(See Figure 5-13).

3 – Mostly full bus with people sitting on every row with only a few seats available and a queue outside the bus. Just as in the café scenario, the user has to join the end of the queue and not push in front. The scenario here is the same as the café, with the user being told by someone in the queue to join the end, as they are being rude and

people were waiting before them. Once successfully in the queue, the user is automatically moved onto the bus to pay the fare and get their ticket. The user can sit on any of the available seats and can do so whether they ask a question or not to the person next to them. The user can ask a question by again clicking on the speech bubble and again a choice of appropriate and inappropriate questions appears.

This time though, when the user clicks on the speech bubble to ask a question they then have to select a person who they want to speak to. This is because there a lot of people in close proximity to the user and it will not be obvious from their orientation whom they want to speak to. If they try and speak to someone who is too far away they will be prompted to move closer. The user does not have to ask a question when sitting down as when catching a bus, if there is an empty seat it is assumed it is available (no toilet or other place for people to have gone to), though of course there is nothing wrong in being polite. So this scenario in conjunction with the café one shows how in fundamentally the same task, different behaviours are deemed appropriate in different contexts.

Figure 5-13: Thought bubble scenario on bus.

5.4 Bus Review

Observations of the bus VE as part of an iterative design process as described in section 3.8 took place again at Rosehill School in group sessions with the same class and in the same manner as described in section 4.6.2. The sessions with the bus environment highlighted why it is useful to use the software in a group session as everyone can learn about the social issues even if they personally are the ones that don't make a mistake. Different strategies or situations not covered in the software could also be discussed more meaningfully with recent events still fresh in the students minds and with the large projected screen of the environment they had just been using still visible, e.g. the students were asked what they would do if all the seats were taken. The following exchange between students (identified as A and B) was typical of the interaction between students and teachers. Student A said they would ask if they could sit down, probably thinking that 'all seats taken' was like all the tables being taken in the café and you therefore had to ask a question to join the table. Student B then said they would stand up, so when Student A still said they would ask a question, the teacher told him that B had a good idea and to ask him what it was. This, according to Atwood and Cray (2001), is critical as peer group acceptance becomes more important than the opinions of parents/teachers as they have a desire to be understood by their friends and will open up more, enhancing the learning experience. The software should also support the teacher in rewarding success and not failure (Heppel, 1994), i.e. the user should not be encouraged to fail so that they can see or hear consequences they find enjoyable, though the impact is reduced when the teacher can intervene and discuss what happened.

In the partly filled scenario most students moved to the empty seats at the back and did not sit beside anyone, which was thought to mean they were displaying appropriate behaviour. The teacher then informed us that most of the students in the class liked to sit at the back of the bus and it was realised that in the previous level they had not sat at the back of the bus because they were behaving appropriately, but because that is where they always tried to sit on a bus. This highlights that it should not be assumed that a student has understood the situation simply because they can restate information (GSSEU, 1998), or in this case appear to exhibit the appropriate behaviour. It also shows why it is important for the teacher to engage the student to find out their reasons behind certain actions so that the discussion can be directed in a way which the teacher will know to be beneficial. This also suggests that there could be unseen problems that could undermine the learning software, highlighting the limitations of the fixed VE design with regards to individual users. For future sessions the back row was filled, but of course ideally the teacher should be able to control such elements to tailor the needs of their own students. This would render the current way of choosing difficulty levels obsolete, as student's abilities would transcend them. In fact it calls into question the whole concept of 'difficulty'. In a learning VE, 'difficulty' might be thought of as simply a sum of parts relevant to the learni ng goal e.g. amount of help given, number of tasks to complete, number of options to choose from etc. when in fact for people with ASDs, what one person might find easy, another would find difficult due to elements not directly related to the learning goal, e.g. colours or sounds used, the gender of the person they have to interact with or just the position of people in an environment. These elements cannot really be grouped into levels of difficulty as they differ in effect from one person to another, much as in the same way as people have different tastes. Therefore the teacher should be able to individualise the VE for their students and instead of describing how 'difficult' a scenario is, instead it could be how 'realistic' the experience is. For example, a teacher could remove distracting objects and sounds or various random elements which will discourage some people with AS and slowly expose the student to them in a controlled manner leading towards the kind of unpredictable, sensory conflicting experience they might face in the real world.

It was also suggested by the teachers that additional levels to the bus scenario were required to cover more possible eventualities. A number of ideas were discussed, before settling on the two listed here which could be achieved in the time available;

- Full bus, but with bags on some seats – The user has to ask the person if they could move their bags so that they can sit down. They can ask politely or not which won't affect whether they complete the task or not, just determine the response of the person who is moving the bags.
- Full bus – The user has to click on handles to stand.

It was also mentioned that the user should have more of a reward in the bus and that should be to go on a journey, perhaps to either the café or job interview. This in turn highlighted a need for an integrated series of modules (like in Virart's Virtual City program – Brown et al, 1999).

5.5 Updated Bus Scenario

5.5.1 New Bus Levels

Two additional levels were added to the bus scenario to incorporate more of the situations that could be expected to be experienced in real life. The first new scenario to be added was where the bus would be full but two people would have bags of shopping on seats next to them (Figure 5-14). The user would therefore need to ask for the bags to be moved, so that they could sit down. The user would get on the bus as before having joined the queue and then getting their ticket. The user then has a few options, they can ask for the bags to be moved, move the bags themselves or just choose to stand. If the user asks a question, then again there will be appropriate and inappropriate choices. The user could select a question which has nothing to do with the task, in which case they will be informed by the program to try something else, they could politely ask for the bags to be moved or they could be rude and just tell the person to move their bags. If the user is rude they will be told by the person that they 'could say please', but the bags will be moved any way. The user then clicks on the seat to sit down and will be told 'well done' if they were polite. Likewise the user could not say anything at all, approach the seat and click on the bags to move them. The passenger next to the bags will then respond by saying 'excuse me, they're my bags, I'll move them for you'. The bags will disappear and when the user sits down they will be told they have found a seat, but not be praised. If the user decides not to ask for the bags to be moved they can click on a handle (Figure 5-15) to represent them holding on and standing up. If this occurs, the user will be told that there are seats available if they had wanted to sit down and are given another try. The other level to be added is where there are absolutely no seats available and so the user is forced to stand.

Figure 5-14: Bags on seat scenario

Figure 5-15: Bus handle for standing

5.5.2 Bus Journey

Once the user has found a seat or decided to stand then they can, if desired, begin a journey on the bus to the cafe. This journey can be seen as a reward to the user as well as offer a link between the café and bus VEs. The user has to learn to recognise landmarks such as the outside of buildings just prior to the café so that they can stop the bus at the correct stop. The level of difficulty on the bus journey relates to the overall difficulty level chosen. In the first few levels the bus stops outside the café even if the user has not pressed the red button to signal to the driver that they wish to get off. Likewise, if the user presses the red button too early they will be informed that this is not their stop and should wait on the bus. They do not have to get off the bus as one of the teachers thought that it may be too much to worry about if you could get off before or after your stop. When the bus reaches the café it remains at the stop and the user is told to get off. The viewpoint switches automatically from the fixed seat position to a standing viewpoint where the user can navigate their way off the bus and approach the café which will then start that VE. These easier levels are so that the user can learn to recognise where they are meant to exit the bus on the harder level. When the user sees the café approaching then they have to press one of the red buttons on the handles, which makes a beeping sound and has the 'bus stopping' light come on (Figure 5-16). The user then has to exit the bus when it stops (Figure 5-17). If they do not press the button in time then they will be informed that they have missed their stop and should press the button to get off at the next stop. The scenario will then restart to give the user another chance at performing the task correctly.

Figure 5-16: Bus stopping light.

Figure 5-17: Getting off bus at café.

5.6 Final Bus and Café Observations

5.6.1 Modifications Required to the General Interface

As the number of iterative design stages progressed, the VEs took shape, with most program bugs being eradicated, the content approaching something the teachers would find useful and the usability of the interface being tidied up. In the last set of observations of the VEs at Rosehill School, the following changes were highlighted.

The ? and ear icons were seen to be mostly redundant and could be replaced by other icons or just removed to prevent the user from having too many options, which can be disruptive and confusing.

It was observed that many students, whilst in the middle of a level would accidentally or intentionally click on another level and therefore not complete the current level they were on. There is never really an appropriate time to disable the level selection interface, as the teacher may want to change the level at any time if they feel a student is having difficulty. Therefore it was decided to remove the interactivity from the interface on the screen and have the levels selected by pressing the corresponding number on the keyboard. The idea was that the student would just use the joystick and mouse to interact with the VE, while the teacher could control events with the keyboard by selecting the levels and resetting or pausing the VEs.

The teachers indicated that there were key moments in the scenarios where they would want to pause the action on the screen almost every time to discuss with the students what was happening and different coping strategies. They thought that it would be better in these cases to have the program pause automatically, with the scenario continuing when the teacher was ready. When the program is paused, it should be obvious what to do to get back to 'active mode', so the pause dialogue box which appears is altered to include the text 'press Enter to continue' to indicate how to carry on with the scenario.

5.6.2 Modifications Required to the Bus VE

The queue to the bus is extended and curved round onto the bus so that it appears more obvious that the people in the queue are getting on that bus and not just waiting there. This should enforce the idea that the user should join the end of the queue and not push in at the front. The user's starting viewpoint is also altered slightly to show the bus door and queue equally so that the program is not suggesting what the user should do.

After the user finds a seat on the bus there should then be the option to go on the bus journey rather than go on it automatically as the teacher may want the student to try certain levels a few times before progressing to the journey. Therefore a text box will appear asking whether to continue with the bus journey. The teacher can then 'press Y to start bus journey' or 'press N to stop scenario' as it will be the teacher's choice at this stage, not the students. If the scenario is stopped then another level will have to be selected.

Levels 4 and 5 are swapped round as 4 was deemed more difficult than 5. This would also allow the student to practise standing up in level 4 and then use it as a strategy in level 5.

These changes described in this section and in 5.6.1 were incorporated into the bus VE design along with a more polished looking interface, screenshots of which can be seen in Figure 5-18 to Figure 5-22.

Figure 5-18: Finished bus VE – Pushing in queue.

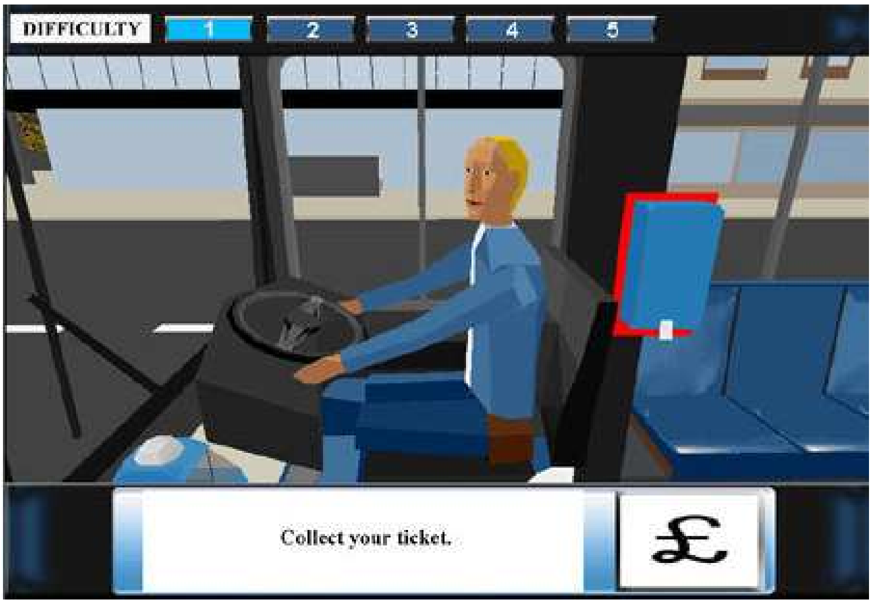


Figure 5-19: Finished bus VE – visual aid for getting ticket.

Figure 5-20: Finished bus VE – Asking passenger to move their bags.

Figure 5-21: Finished bus VE – Deciding to go on bus journey.

Figure 5-22: Finished bus VE – Approaching café after getting off bus.

5.6.3 Modifications Required to the Café VE

When joining the end of the queue, instead of immediately moving forward to get food, there should be on the harder levels progressively longer times to wait before the user gets their food. This means there is the opportunity for the user to be impatient and leave the queue, making it more realistic. If this happens, the user will be informed and will have to rejoin the end of the queue.

There should be more menu options in the café with healthier options to pizza or chips. Even though most students would have a favourite food that they would most likely always go for, the teachers always try and get them to have something more varied and healthier if need be. Food should also be added to tables where people are sitting to make it look more realistic.

The ability to click both seats and tables to sit down needed to be added to all table groups using the *actchild* command. This means that instead of having the code check whether specifically named objects have been selected (in this case chairs or parts of a chair), all the objects at a table (table, chairs, people etc) are put into one containing group and therefore become children of that group. A piece of code can then check to see if a child of the group has been selected. This is easier to program and it also allows the user to be less accurate in moving the mouse pointer over a seat which, depending on their viewpoint, could require fine motor skills which they may find difficult and frustrating.

The screenshots shown from Figure 5-23 to Figure 5-27 illustrate some of these changes in the finalised beta version of the café VE.

Figure 5-23: Finished café VE – Random layouts of café.

Figure 5-24: Finished café VE – New larger menu.

Figure 5-25: Finished café VE – Varied questions to ask people at tables.

Figure 5-26: Finished café VE – response to seat availability.

Figure 5-27: Finished café VE – completed task sequence.

5.6.4 Effectiveness of VEs

The research in this thesis is concerned about structuring VEs to aid learning by allowing them to be 'usable' in the classroom. It does not look into whether they are effective in terms of a transfer of learning. Transfer of learning is extremely difficult to prove, especially in the short term (Cobb, Neale and Reynolds, 1998). A couple of studies however were carried out at the end of the AS Interactive project by the psychology members of the team to investigate the effectiveness of the VEs (see Leonard et al, 2002; Parsons et al 2004b for more details) and are summarised here.

Both papers report on a series of evaluations where participants used the cafe´ and bus VEs over a number of sessions, in a structured format. Video clips of real buses and cafes were also viewed by participants to ascertain whether any of the knowledge gained during use of the VEs would transfer to discussions of where to sit in a real cafe´ /bus. Additionally, there was a followup session after three months, to check whether any learning or understanding gained from the VE had maintained over the summer school break. Parsons et al (2004b) were looking at qualitative data on two male participants aged 14 and 17 while Leonard et al (2002) did a quantitative study using error and time measures on seven participants, four male, three female aged between 14 and 16.

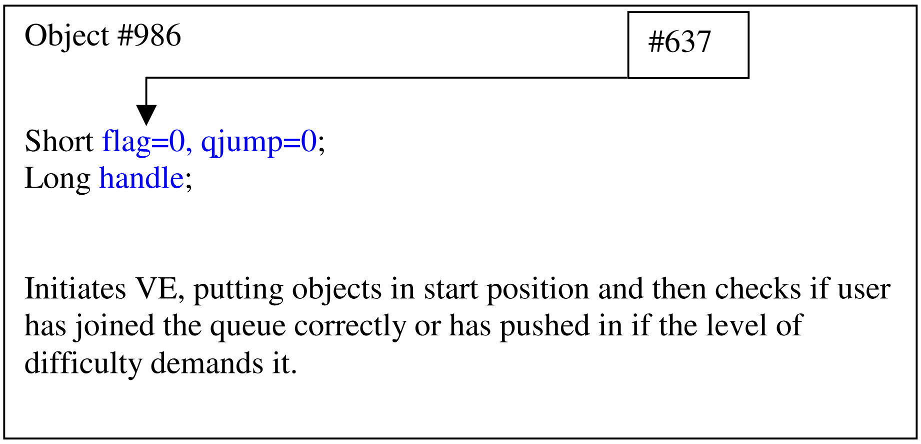
Parsons et al found that both their users seemed to be very motivated by the VEs, even after a number of (very similar) sessions, and both stated that they enjoyed the sessions. Although 'level of enjoyment' is a difficult concept to convey in a limited space and without quantitative questionnaire responses, the fact that both participants stated explicitly that they liked using the programs is encouraging. Generally, there was a very positive response to the VEs and there was also evidence that the users had remembered social knowledge gained during their VE sessions. In addition, both participants appeared to have a good understanding of the purpose of the VEs and were able to offer specific examples of how it had helped them now, and could help them in the future. These observations suggest VEs could offer an additional tool for useful and meaningful social skills training opportunities in the classroom, perhaps as an augmentation to existing methods and approaches.

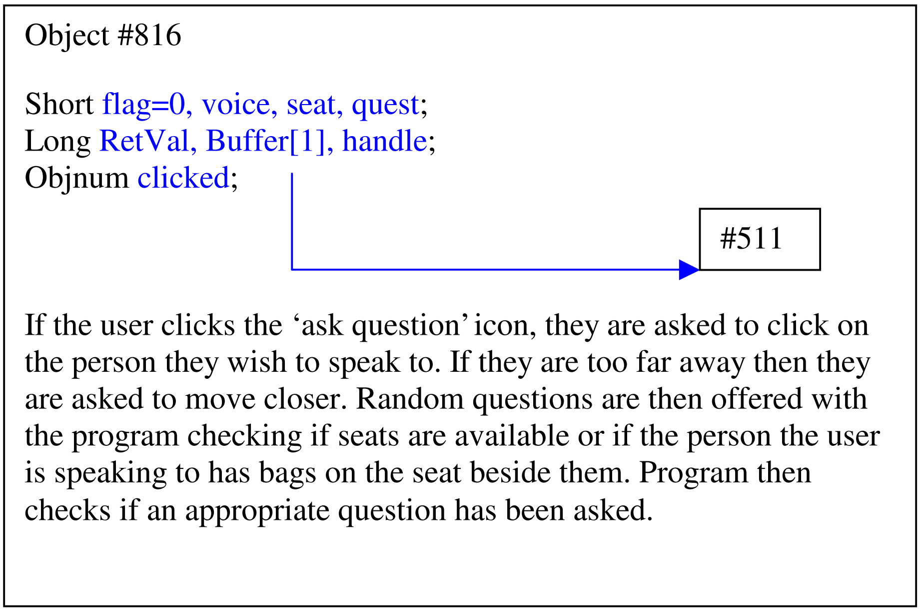
Leonard et al found that most students in their study were able to learn the appropriate responses through the interactivity with the VE, and did not have difficulty in coping with the negative feedback that an inappropriate behaviour initiated. The students listened to the advice given by both the facilitator and the program and did not continue to make errors which the program was directly confronting. There was strong evidence that most students showed an improvement in social judgements in after using the café VE. Some students showed some crossover between contexts, but generally the learning was context specific and it was not possible to determine whether students could generalise if specifically asked to do so.

5.7 Code Structure

5.7.1 Bus Code

The following diagrams show the different objects in the Bus VE that contain the main code for controlling what happens in the learning scenarios. Instead of there being just one long piece of code, it is split into modules, each with a specific role. This is loosely based on the object-orientated method of programming (Sun Systems, 2005) which allows for easier visualisation of what the code is doing by breaking the code into more manageable parts. It is also more scalable, so that new pieces of code can be added at a later date, relatively easily. The modules of code are linked, by communicating with each other, via their variables. These can send messages from one module to another to either trigger another module's code or to affect the value of the variable which in turn affects how the piece of code runs. The following diagrams show the variables in each module and how they affect or are affected by other modules via the arrows linking to (blue) or from (black) a list of those modules. A short description of what each module controls is also shown. It should be noted that the modules have a name as well as identifying number in the VEs, but the object numbers are just shown here to fit within the diagram.





Object #637

Short flag=0, difflev=1, avail[14]={0,0,0,0,0,0,0,0,0,0,0,0,0,0};

#986
#816
#893
#382
#511

Determines visibility of people on bus, queue and bags depending on difficulty level.

Object #893

Short flag=0, stand=0, attempt=0
Long handle
Objnum standh;

Checks if user has clicked on a handle in the bus and then, depending on the difficulty level informs the user if there are seats they can sit on or makes sure that the user definitely wants to stand on the bus.

Object #382

Short flag=0, busstop=0, busdest=0, check=0, noiz;
Long OldTime, handle, x;

The code on this object controls the bus journey, giving the vehicle the relevant dynamics and checks when (if at all) the user presses the button to inform the driver that they wish to get off at the next stop. If the difficulty level is easy then the bus will stop outside the café regardless of the users actions.

Object #511

#986

Short check=100, flag=0, buspass=0, voice;
Long newxpos, newypos, newzpos, OldTime, noiz=0,
handle, x, RetVal, continue=0;

#893

Checks to see if user pays fare (triggers coin and ticket animation) and collects ticket. Then checks to see if the user sits on an available seat, a seat with bags on it or next to someone when there are empty double seats available. Automatically pauses the action at certain sequences.

5.7.2 Café Code

The following shows a breakdown of the code structure similar to that described in 5.7.1.

Object #3

Short flag, seats, stand, avail[7];
Objnum obnear;
Long handle, astime, stillxp, stillzp;

#1203
#404

#404
#1063

Controls what happens when a user nears the tables and tries to sit down. Only allows interaction depending on difficulty level and seating availability.

Object #1203

Short flag, difflev;
Long RetVal, Buffer[1], handle, astime;

#3
#1063

Program checks if user has joined the queue correctly or has pushed in and if so starts that scenario. The user is then moved to the counter where they are given a menu choice and can select which food they want before going to the till and paying.

Object #404

Short flag, asked;
Long RetVal, Buffer[1], handle, quest;

#3

Provides a random set of questions which the user can ask when talking to people at the tables. Program checks appropriateness of users question and responds depending on the availability of seats at that table.

Object #1063

Short difflev;

Determines what is visible or invisible (people at tables, people in queue, people walking or standing in café and plates of food) in the café at beginning, depending on what difficulty level is selected.

Object #1112

Short flag;
Long OldTime, handle;

#1063
#1113

Controls background sound heard in level 4. Plays small wav file in continuous loop until other level chosen.

Object #1113

Short flag;
Long RetVal;

Pauses entire VE by displaying a dialogue box which remains until ‘Enter’ is pressed.

Object #1114

Short flag;
Long floor, newpos, oldpos, tabgp[7], gpmarker[7];

Displays random décor and queue as well as give random positions to the table groups.

5.8 Discussion and Conclusions

Observation studies (see sections 4.6, 5.4 and 5.6) of use of single user virtual environments in the classroom found that the VEs were used to support teaching in different ways (Neale et al, 2002):

1.Individual tuition (with the teacher alongside the student) was useful in gauging the suitability of the program for individual students and identifying their level of understanding.

2. Group exploration and reflection (where a teacher led a discussion with a small group of students viewing the VE on a projected screen) was useful for identifying social cues in the VE and understanding the perspectives of others.

On the basis of these studies, a number of recommendations for improvements to the VEs were made, in order to maximise their potential as a teaching resource in the classroom:

- stages need to progress gradually, allowing participants to practise and learn skills at a basic level before moving onto more complex situations
- similar scenarios should be presented in different ways (visually distinctive) in order to avoid the possibility that participants could rote learn responses
- allow the teacher to tailor the VE to cater for individual needs e.g. control the number of people/available seats in a scene, or insert pictures of familiar faces on avatars.

Using a social skills learning VE in the classroom as part of a group lesson and discussion, appeared to be successful and offer great potential. Group discussions, guided by the teacher and following appropriate, interactive, experiences can be directed in a meaningful way to the students concerned who are more open and involved when learning with their peers. The role of the teacher as a facilitator to learning is extremely important as they have an understanding of the students' needs which the software cannot possibly replicate. Skilled teachers can use the program, like any other tool, as an aid to this learning, rather than an all encompassing solution. The teacher therefore has to feel that the program does indeed offer this ability as an aid and can be used effectively and easily. It is important therefore that there is early teacher input and collaboration in the software design and that the program has the support of the school and department heads.

A successful VE for teaching social skills to people with Asperger's Syndrome will have to have sufficient scaffolding inbuilt into it to automatically guide users through the learning process taking into account as many eventualities as possible while also having the flexibility to adapt for unforeseen problems through teacher intervention e.g. pause button as used by Ehrich et al (1998). This conforms to the idea that a teaching strategy somewhere between the constructivist and instructional methodologies are best suited for people with autism (Dick, 1992, Autism Society of America, 2001). Practical problems in using the VEs might include the user trying to activate icons and objects when they should not. This requires the icons or objects to be disabled or for the user to be informed why such an action is inappropriate at that time and for alternative options to be offered. Ease of navigation and orientation should also be supported, with obstacles removed or invisible channels made and with auto viewpoints when the user is required to be looking at something at a given time, reducing the frustration felt by users trying to control their movements, but still empowering them with autonomous control.

The learning of metaphors used in the software should be as intuitive as possible, though there will need to be a certain amount of training for these. It has been shown that this training would be better inbuilt into the actual learning scenarios themselves, though after a relatively short period of time, and with the help of teachers, the student with AS usually picks up what the interaction metaphors are. There will be some preparation needed by teachers beforehand and the software should fit into part of the overall learning strategy used by the teacher as how the software is used is critical. The software will not only have to be relevant and fit into the teacher's strategy, but be varied and interesting enough to cover all issues which the teacher wishes to look into and to hold the students' attention and enthusiasm, outcomes found also by Crosier et al (2000) as well as Huntinger and Rippey (1997). This is why it was seen as successful when the updated café and bus scenarios were used together as there was enough content to allow different members of the class to try something different while the rest of the class discussed what was going on and the varying levels of difficulty also allowed different members of the class to experience something challenging. The fact that the interface to both scenarios was constant and interaction metaphors were also maintained allowed the students to experience a vast range of different scenarios in a relatively short period.

After the review of the bus VE (section 5.4), it was suggested that it might be beneficial if the teacher could intervene before each user started using the VE learning scenarios by structuring the VE to suit the needs of the individual, e.g. in the bus and café environments, the teacher should be able to decide where the virtual people are sitting and even what questions the user might be likely to ask. This would in some ways negate the need for elements of the program to be randomised as each time the student used the program could be a very different experience. Randomisation though is very important in designing learning software for people with autism so that they have to think about their decisions and not just learn things by rote. As the VE scenarios were quite rigid and very specific, it was felt they only offered a generalised experience of the events, something which people with AS have difficulty dealing with, so a program which could relate real meaning to a specific user could be extremely beneficial. This individual adaptation, along with good class preparation by the teacher could pave the way for an enriching learning experience for both teacher and students and could be utilised by a far greater number of both. While the prospect of such programs seemed initially quite daunting, it was imperative that such behaviours were looked into to see if initial reaction by teachers to such programs were favourable, especially regarding their ease of use.

The modulated structure of the code in the bus and café VEs should mean that any changes to allow for individualisation will just be modifications and additional code, rather than having to make wholesale changes, effectively meaning starting from scratch.

Table 5-1 summarises the recommendations discussed in this section, not already covered in Table 4-2. The recommendations here can be relevant to mainstream education VEs as well as those specifically for people with ASDs.

Recommendation
Allow gradual progression in learning
Involve teachers early in design
Have sufficient scaffolding to guide user in learning
Disable features when not required
Allow ease of navigation through layout design or automatic movements
Learning VEs should fit into overall learning strategy
VEs should be varied and interesting
Have uniform interface
Allow VEs to be tailored by teachers to meet the needs of individual users.

Table 5-1: Learning VE Recommendations

Table 5-2 and Table 5-3 show the scaffolding specific to the difficulty levels (levels 1 to 4 or 5 going from most easy to most difficult) in the café and bus VEs. These relate directly to the learning task and do not include the general scaffolding such as automatic viewpoints and navigation aids that are present throughout the different levels of the VEs that aid the usability of the environments.

	Level 1	Level 2	Level 3	Level 4
Cues	Indicate where to go and what to select at any given time with red flashing panels	-	-	-
Stimuli	Empty cafe	People in seats and small queue	As level 2, but with large queue and people standing around	As level 3, but with people walking around as well as standing and background noise.
Navigation	As stimuli increases in terms of number of people in café, it becomes harder for user to navigate around the café with the extra task of joining a queue.			
Selection	As café gets busier, more possible interaction choices become available to the user as they are forced to ask people if they can sit beside them.			
Feedback on finding seat task	User told what to do, e.g. click on table to sit down.	User given options as what to do, e.g. you can sit down, ask people if you can join them or move to another table.	-	-
Feedback on actions taken by user		User given feedback on their actions, e.g. told they have moved away from an available seat or have sat down at an unavailable seat and should stand up and look for another table.	As level 2	As level 2
Feedback given to questions asked by user		User told on first appropriate question that seat is available.	As level 2	User told on first appropriate question that seat is unavailable. User has to go to another table and ask appropriate question again to find available seat.

Table 5-2: Scaffolding specific to difficulty level in café VE.

	Level 1	Level 2	Level 3	Level 4	Level 5
Cues	Indicate where to go and what to select at any given time with red flashing panels	-	-	-	-
Stimuli	Empty bus	People in seats and small queue	Large queue, most seats filled.	Large queue, full bus.	Large queue, full bus, but with bags on some seats, background city noise.
Selection	As bus gets busier, more possible interaction choices become available to the user such as asking for bags to be removed or choosing to stand.				
Feedback on finding seat task	User told what to do, e.g. click on seat to sit down.	User told if seats are available when they have chosen to stand.	As level 2	-	As level 2 – help given here as this is first time bags appear on seats.
Feedback on bus journey	Bus automatically stops outside café if user does not press button in time. If button is pressed too early then user told to wait on bus until they get to the café.	As level 1	User told if they press button to get off bus too early or too late and retake journey.	As level 3	As level 3

Table 5-3: Scaffolding specific to difficulty level in bus VE.

5.9 Summary

This chapter has looked at the continued scaffolding of the VEs, including the dynamic interface and random elements of the learning environment to aid usability and learning was examined as well as how the code for the VEs was structured. Observations of the VEs in use showed how different elements of the program were utilised, but with the discovery that future research should look into how learning VEs could be adapted to suit each and every user.

Chapter 6. Individualised Learning

6.1 Introduction

Conclusions drawn at the end of the previous chapter (and end of the AS project) were that VEs for teaching social skills to people with ASDs need sufficient scaffolding inbuilt while also having the flexibility to adapt for unforeseen problems through teacher intervention. Allowing a teacher to individualise the content of the VEs in some way is important, as it should not be assumed that a student has understood the learning objective by appearing to exhibit the appropriate behaviour for the given task. However, this flexibility of teacher control should not be added in to the VE as an afterthought, it should be inbuilt into the construction of the VE from the start. This chapter looks at research continued after the end of the AS project by the author, examining issues behind individualised learning and how learning software can facilitate such a paradigm. A literature review of current research is presented to determine what features are required for individualised learning software to be successful from both a theoretical and practical viewpoint, including its implementation into a teaching strategy within the classroom by teachers. It can be seen that there is actually no research mentioned in the literature about individualising software programs for people with special needs such as people with AS, which is no great surprise as it is only just becoming an issue in mainstream education. The literature discussed here though can be used to point out issues which are relevant to people with AS and can be used in designing applications for them, though the collective issues raised can point to features beneficial to mainstream education also.

While the typical elements and features that should be incorporated into an individualised learning VE are discussed, there is a requirement for a prototype to be developed to investigate their value. To help develop this prototype individualised VE, it was necessary to develop some simple VEs, to demonstrate some of the features that could be adapted and how this could be achieved, making it much easier for autism professionals in the project to visualise the options and give a more significant contribution to the input of ideas for the design. This chapter describes the development of two such demonstration VEs that contain two new scenarios set in a bank and a post office with the common theme being queuing. These VEs provide additional contexts for queuing along with the café and bus VEs to see if presenting the same task in as many different contexts as possible is worthwhile and what other tasks might benefit from such a strategy. They also show how some of the layout of the VE can be chosen to effectively alter the learning experience of the user. The demo VEs were shown to a number of autism professionals for comment and feedback, which was obtained through an interview and expert review. This chapter also looks at how the overall thinking behind the structure of the program code evolved along with the VEs to find an effective way of developing an individualised rather than level based learning VE.

Figure 6-1 shows a model for the development of the individualised VEs with this chapter concluding on the evaluation of the Demo VEs, leading to the development and evaluation of a prototype individualised café VE in Chapter 7. It should be noted that the design cycle here is different to the model used in Chapters 4 and 5 as the author no longer had the support of the AS project team. It was therefore not possible to conduct user (students in classroom) evaluation studies (see section 1.4.2).

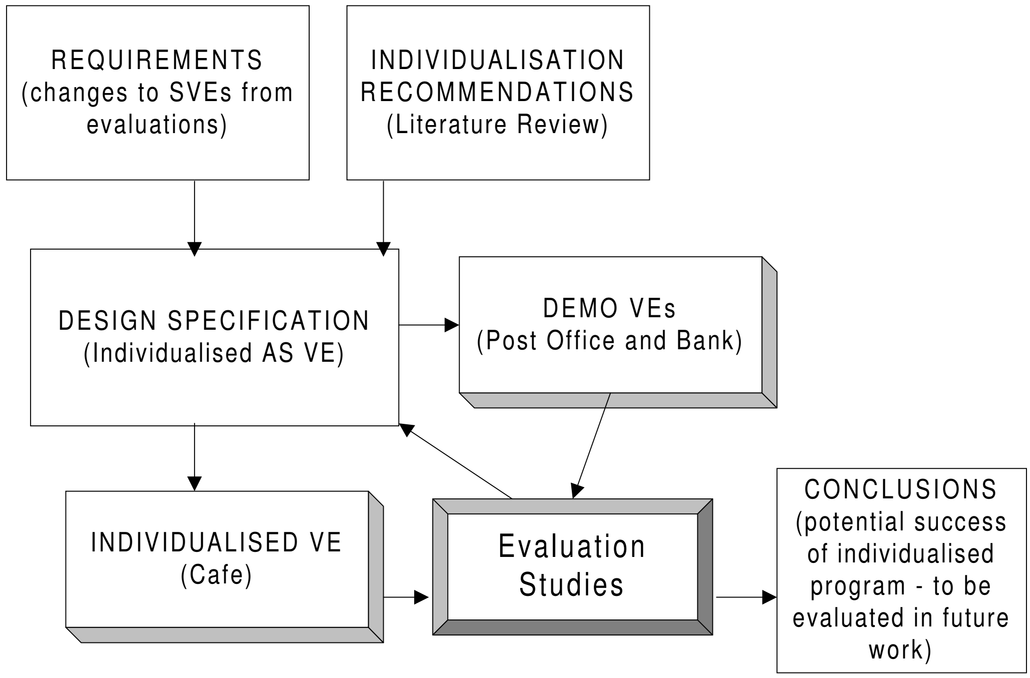


Figure 6-1: Model for Individualised VE Development

6.2 Literature Review - Individualised Learning VEs

6.2.1 Computers and Learning

Computer programs have been used for learning (albeit not extensively) since the 1960s (Becker and Hativa, 1994). Taking advantage of computer technology, learning software was developed which allowed the student to learn, not passively soaking up information in a linear fashion, but interactively at their own pace in a non linear way, getting instant feedback and help (Chen, 2002). As computers became more powerful, and therefore the software too, the learning experience was able to become more sophisticated, offering a more varied and multimedia rich experience to the student. Inbuilt into the software could be varying degrees of difficulty to take into account the different levels of ability of the student. However this is a generalisation of ability and doesn't take into account specific individual differences of the student. The learning scenarios of the bus virtual environment, described earlier in this thesis, have varying levels of difficulty from an empty bus to a full bus, with other challenges such as bags on seats and having to stand added as things got more complicated. What the VE does not take into account is individual differences that would make a supposed easy scenario for one learner, quite difficult for another, e.g. a person with autism might have a favourite seat they sit on and the only person in the bus is sitting on that seat, or the colours and language used would be a problem to the student (see sections 2.9 and 5.8). What we see here is indicative of not just learning software but teaching methods in general. Sokolov (2001) refers to this as the flaws of mass education, being tailored to the average student and represents a loss in human development potential as clever and not so clever students are exposed to the same challenges.

6.2.2 Mass Customised Education

Sokolov highlights how educational practice has followed closely to technological advances and manufacturing practice. Once, if a person wanted shoes, they would go to a cobbler and get a pair made just for them. The shoes would fit perfectly and be exactly as the customer wanted, but they would be relatively expensive. At the same time education was likely to be 'one on one' by a tutor but could only be afforded by the well off. Innovations in mass production meant that shoes could be produced in large numbers at low cost, but they would have to be in a limited number of sizes taken from an average, not custom built for the specific needs of the customer. The advantages were that a person could now buy a pair of shoes quickly off the shelf at a lower cost, but they would have to find a 'best fit' or look around for a style they liked, which many other people would have. Likewise in education, schools came into being where mass produced material could be taught (in forms of textbooks and curricula) to many people making it cheaper and accessible to the masses, but again a 'best fit' to the average person was required. Today new technologies and procedures as well as new methods of managing makes it possible to provide each customer with the 'tailor-made' benefits of preindustrial craft at the low costs of modern mass production (Sokolov, 2001). Education again looks set to follow with what Sokolov refers to as Mass Customised Education (MCE) and noted that Reigeluth (1997) concluded that an education system that is focused on learning rather than sorting requires customisation to replace standardisation.

It can be seen that it is only with the advancement in technology that MCE is now possible and this is reflected in the relatively small amount of literature on the subject (Sokolov, 2001). In the 90s, Jih (1996) pointed out that courseware for learners who have previous knowledge of and experience with multimedia/hypermedia needs to include more features to attract a learner's attention. Such features could include being able to adapt the software and experience to match their own needs and requirements.

Squires and Preece (1999, p478) then stated that "*being able to tailor the interface to support an individual learner's needs and learning strategies will become increasingly important as learners become more sophisticated computer users. As a focus on individual learning in the home increases, the need for bespoke versions of the software will increase. This aspect of flexibility is set to become more and more important.*"

It can be seen therefore that there is a need for learning software that can be individualised to the user either by themselves or a teacher. Liber et al (2000) agree, saying that well designed information technology systems can help by providing tools to support more individualisation and better communications.

In today's fast changing world an education system which teaches knowledge and skills to be retained over a lifetime would appear outdated with only social skills being permanent, but with an ever shifting knowledge base (Sokolov, 2001). This shows that social skills are fundamental in education, but that teaching methods have to be flexible to cope with our ever-changing environment. MCE seems to offer a responsive and efficient knowledge acquisition system for preparing human resources needed in the 'new' evolving society, in a humanistic, interestin g and cost effective manner. MCE can provide a learning experience that can be tailored more appropriately to the individual with inbuilt agents/scaffolding, which can either give guidance or can flag to the teacher that help is required. This keeps teachers in the learning loop and their important guiding role (Sokolov, 2001). This as Jih (1996) notes also conforms with Guided Discovery learning where students discover and learn for themselves, but with the guidance of teachers, and is an effective method of teaching.

Hardaker and Smith (2002, p347) also note that "*collaborative learning through the Internet is seen as a natural extension to the exploratory-based style and provides a vehicle for the transformation from tacit to explicit knowledge creation. As it indicates, this type of learning is group based and as a consequence typically relies on customisable groupware products that are now widely available through 'off the shelf' MLEs (Managed Learning Environments), designed specifically for the Internet*."

Explicit knowledge is typically quantifiable data such as words and numbers, while tacit knowledge is not as easily visible and quantifiable. Typically, tacit knowledge is hard to formulise, due frequently to its personal form, and as a consequence often problematic to communicate in a controlled way across computer networks. Hardaker and Smith (2002) continue that interactive learning enables group based tacit knowledge creation from individual explicit knowledge creation. In other words, students can only collaborate and discuss ideas if their initial thoughts/understanding are based on information that is meaningful to them personally. Therefore, designers must take human factors within learning courseware interaction into account, a factor that is not new, but was stated by Jih back in 1996. The features required within the individualised software as well as how it is implemented will be looked at in the following sections.

6.2.3 Implementation of Individualised Learning

6.2.3.1 Environment

For individualised learning software to be truly effective, it not only will have to include the required content and features to facilitate customised learning, but it will have to be implemented and used in an environment which is supportive of its principles and allows its true potential to be realised. Sokolov (2001) suggests that this supportive environment can be a classroom that promotes discussions of the subject matter in a competitive manner and that from a knowledge acquisition viewpoint, the strategy of running a school should be like running a hospital in that no two patients or students are the same. Therefore the individual has to be assessed and given a tailored course of treatment (educational program) with follow up systems to chart progress and achievement before being discharged (graduating).

6.2.3.2 Lesson Strategy

Lee (2001) summarises that at the lesson level, predominant decisions are organizational strategy decisions, which refer to how instruction will be sequenced, what particular content will be presented, and how this content will be presented. Gagne et al (1992) suggested lessons should include nine ‘events of instruction’:

1. gain attention
2. inform the learner of the objective
3. stimulate recall of prerequisite learning
4. present stimulus materials
5. provide learning guidance
6. elicit performance
7. provide feedback
8. assess performance
9. enhance retention and transfer.

Lee (2001) states however that other important events such as procedural rules and psychomotor skill learning have to be considered in order for learners to use learning software. Motor skill learning is best accomplished by repeated practice while in procedure learning the best strategy appears to be a straightforward presentation of the procedure with demonstrations of the applications of the procedure (unless the primary goal is for learners to acquire skills in generating procedures) (Lee, 2001). This conforms with how the VEs in the AS project were developed, as the user learns how to use the interface to the VEs while undertaking the learning scenarios in the easier levels which they can practice repeatedly until understood. However in the AS VEs it is by trial and error (with help of guidance) that the user must learn the social skills (the procedure) rather than just learning a sequence of events by rote.

6.2.3.3 Teacher Role

Education software is a tool that must be able to be incorporated into lessons by a teacher and not necessarily replace the lessons. Software should fit into part of the overall learning strategy used by the teacher, as how the software is used is critical (see section 2.7.3). The AS project found that with early teacher input and collaboration and with the support of school and department heads, using a social skills learning VE in the classroom as part of group discussions, appeared to be successful. Teachers could guide these discussions, following appropriate, interactive experiences effectively as the program allowed them to do so (see section 5.8, also in Kerr et al, 2002). This fits with Pahl's (1999) statement that the role of the educator changes from a teacher to facilitator and manager, while Sokolov (2001) points out that the MCE system does not expect the teacher to be a source of knowledge, but take the role of a guide, teaching basic skills and focusing on the social and study atmosphere of the class.

Squires and Preece (1999) describe how teachers will often feel the need to adapt software to the specific needs of their students or to match lesson requirements. They state that a good feature of an educational application is the facility for the teacher to customise the application, though they are primarily discussing programming languages and spreadsheet*s*. This may be applied to the AS social skills learning software, whereby construction of the VE to allow teacher controlled variation in presentation of the scenario (e.g. change the order of sequence, positioning of characters, visual appearance of scene, etc) may prevent learning by rote and may encourage users to recognise generic cues to help them identify the appropriate response.

In a mainstream school, the use of learning software will require inbuilt tutors. Tutors (or agents) is another type of scaffolding in that it is a program to guide and help students, but specifically they are pieces of code which monitor a student's progress with the learning software and either automatically intervenes when necessary or alerts the teacher that the student requires help. Boyer et al (2001) state that in ever increasing class sizes it becomes more important for a teachers attention to be focused on significant events. Therefore the teacher has to be alerted when special events occur (or do not occur), these features being set by the teacher due to their different nature and levels of importance. However, in a school for people with ASDs, the teacher is involved more one to one, or in small manageable groups so is likely to always witness when a user is having difficulties. The system though should still flag up when the user is making incorrect choices as the first the teacher might know of a problem is when the user is frustrated. It is more desirable to reduce frustration and therefore the system should be able to suggest possible courses of action to both user and teacher.

6.2.3.4 Flexible System

Pahl(2003) informs us that educational systems have to be designed and developed with change and evolution in mind as IT and educational technologies are evolving constantly while courses taught are subject to constant change for organisational and subject-specific reasons. Content change may be due to a course moving to another year or improvements in technology (hardware and software), which would also require system change. Course delivery will be affected by staff changes, including educators, course developers and technical support, particularly if a course was tailored to a specific teacher or method. Content changes and updates are usually easy to carry out – at least as long as text is the medium. For audio and video material, more technical preparation is needed. E.g. for audio recordings a problem can arise if the previous speaker is not available any more. It is essential therefore that change has to be anticipated and reflected in the design of learning software and what is sought is an incremental, iterative method for ongoing construction and reconstruction that can cope with the changes that are required (Pahl, 2003). Pahl (2003) concludes that, from the evolution of learning devices, courseware should be designed with open, flexible and interoperable architectures in mind. Therefore when constructing individualised VEs for teaching social skills to people with AS, a program developer will not just have to consider which features are adaptable, but also how the system may be used in the future and if any content is likely to be needed to be changed, removed or added to. Of course nobody can anticipate all the possible changes that may be required, but the VE can be programmed in such a way that allows changes to be made as easily as possible.

6.2.4 Current Research and Feature Requirements

Boyer et al (2001) note that most research effort has been focussed on designing systems that meet the needs of students, rather than assisting teachers. Jih, (1996) also notes that there is little empirical research on discovery learning with interactive courseware with past studies emphasising performance measures, not process measures. More data resources of users' interactive behaviours collected by a variety of approaches should be explored, e.g. observing user learning to navigate courseware or asking learners to explain the courseware to new learners. Thus, there is very little research into individualised learning programs, which is perhaps not surprising when looking at the amount and type of applications available (see section 6.2.5). Any research that is being carried out tends to concentrate on proving a transfer of learning (performance) rather than whether the software is an effective learning tool and can be utilised effectively by teachers (process).

Sokolov, (2001) states that software is still not able to process natural language or open questions asked by a student and therefore cannot determine where students fail to grasp the studied material if a teacher is not present. Programs can only test the student's knowledge by multiple choice questions or by questions having a fixed value as the right answer. To alleviate this problem, learning software should have intelligible and concise content (to the point and not too large), offer feedback to the student, should be attractive and informative, using all multimedia gimmicks and tricks to achieve this. A monitoring and alert system is also required which can monitor the student's progress and alert if unusual problems are encountered and such a system should allow for intervention and problem solving by the teacher and/or the establishment. There also needs to be a supportive environment that promotes discussions and a conducive learning atmosphere. Pahl (2003) adds that any course content produced in less flexible platforms (such as HTML) should be re-engineered into more flexible representations (such as XML, a key to adaptive and personalised systems), while teaching and learning environments should be scalable, configurable and interoperable in order to deal with change.

Assistant agents which are pieces of code that monitor a program's use by a student and can then either automatically intervene if the student has difficulties or alerts a teacher are seen as important elements of an individualised learning program. Boyer et al (2001) investigated applying assistant agents that continuously tried to detect abnormal events during the interaction between the student and the system, waking up when required to give feedback to the student while transmitting an alarm to the teacher. An assistant agent could also serve as an intelligent interface for the teacher, collecting all the signals coming from students' assistants and provide monitoring views of what is happening for each student. These agents described here are particularly useful as Jih (1996) points out, for monitoring a virtual class composed of many students. In a special needs class where a teacher is more likely to be on hand continuously to monitor a student, the program's job, apart from pointing out errors and coping strategies could be to record key events which might prove valuable to future sessions, especially if parameters to be customised were dependent on these results. Agents are effectively a form of scaffolding and so even if not used in the exact way described by Jih or Boyer, can have many useful implications for the scaffolding used to support the learning experience of people with AS when using a VE.

6.2.5 Current Applications

"*Many software applications are now available for the university and college sectors, including Blackboard, WebCT, LearningSpace plus many more. Some of the products are more customisable than others and as a consequence this affects if they are specific to the education sector or if they are also applicable to more commercial organisations of various industry sectors*." Hardaker and Smith (2002, p347).

Hardaker and Smith are referring to overall education management tools, which as we shall see in this section form the bulk of customisable educational tools available. While the research in this thesis is concerned with a specific individualised learning application for people with special needs, examining these commercially available management tools can give insight into features that are viable for learning scenarios and to see how such scenarios could fit into an overall teaching strategy. By listing and discussing these tools, it becomes apparent that technology is being used not surprisingly at a large end commercial scale which can make organising teaching more efficient and relevant to students, but does not include much in the way of individualised learning applications and especially none for people with special needs.

Learning Space from IBM Lotus Software (www.lotus.com 2003) is an e-learning technology platform that includes both self-paced and collaborative learning capabilities. There are two key modules (Core and Collaboration) that enable organizations to choose the functionality that best matches their needs. The Core Module uses active server page technology and relational database structures to support the delivery and tracking of online self-paced learning content that can be highly structured to suit individual learning needs. The Collaboration Module enables learners and instructors to work and learn together using discussion databases or real-time virtual classrooms. Learning Space though has now only just been discontinued with users being recommended to switch to software such as Lotus Learning Management Systems. Learning Space came from IBM's Mindspan Solutions group who offer customized solutions to learning requirements to be more effective than off-the-shelf options. They use rapid application development techniques, as well as specialized tools that speed the entire content development process. This of course is Mass Customisation at work though the programs here are customised to the individual college or business rather than customising each learning experience to individual users.

The *Blackboard Learning System*™ (www.blackboard.com 2003) is a web-based software system for course management and has a modular architecture to allow customisation. It enables web-enhanced classroom-based teaching and learning, blending the benefits of face-to-face and online learning through the use of hybrid courses. This tool is primarily about managing course content, allowing teachers to create and organize content such as powerpoint slides, web pages or other publisher-created material in a structured environment where the headings, labels, colours etc, can be customised to fit into the structure/syllabus/style of their learning establishment. It also allows for online assessment with customised feedback for correct and incorrect answers, grading and sorting, while complying with Section 508 accessibility regulations. Section 508 is a standard for US Federal agencies that electronic and information technology be accessible to people with disabilities and is similar to the Disabilities Discrimination Act (DDA) in the UK. While this type of customisation (as with LearningSpace) is at a higher (organizational) level than we are primarily interested in, it nevertheless contains important features which are relevant to individualisation for the learner, and as mentioned earlier for true customisation to take place at the individual level then the system/organisation at the governing level has to be flexible and support this as well.

Like Blackboard, *WebCT™ Campus Edition* (www.webct.com, 2003) is a course management system, where again, content such as powerpoint slides can be added with design wizards which allow the teacher to easily set up things such as discussion forums, thus again showing that this type of tool is best for managing content change and is customisable in terms of syllabus and style. WebCT utilises flexible XML technology and is a contributing member of the Instructional Management System Global Learning Consortium (IMS) enabling specifications for content migration, data sharing and system interoperability. Third party, customised, learning applications provided by partners in the WebCT Learning Innovations Network can be integrated into the management tool. Publishers McGraw-Hill are providers of online content of their educational material which teachers and students can choose to piece together in any order using WebCT and other management systems such as PageOut, ecollage and TopClass to provide tailored courses.

Pearson Digital Learning (www.pearsondigital.com 2004) provide a number of learning solutions which fit in the modern e-learning classroom. In particular they provide content solutions such as KnowledgeBox and SuccessMaker Enterprise which can be customised to fit the learners needs. KnowledgeBox allows teachers to integrate into their everyday instruction digital media from across a wide range of content areas. It is designed to support various instructional styles and approaches whether a student is working independently or within small group activities, allowing teachers to customise existing lessons or build their own lessons to meet each student's unique needs.

SuccessMaker Enterprise (Pearson Digital, 2004) offers core learning such as maths and English along with science and social studies. SuccessMaker individualizes instruction to the specific needs of each student by:

- Automatically presenting instruction at the level at which a student is ready to learn—a level neither too easy nor too difficult—creating a successful learning experience
- Adjusting the presentation of content to find the optimal sequence of instruction based on student response
- Guiding learning by employing a variety of instructional strategies when a student has difficulty and providing multiple opportunities to master each concept
- Periodically activating retention checks during the learning process to ensure retention of previously presented skills
- Emphasizing specific content areas where students need to focus.
- Reporting powerful data to identify student areas of difficulty and help teachers effectively target instruction

6.3 Recommendations for Design of Individualised AS VEs

In summary from sections 6.2 to 6.2.5, it can be seen that Mass Customised Education would appear to offer a pedagogical framework that gives provision for a learning experience that can be tailored to the individual, an important requirement in teaching software for people with autism (section 6.2.2). Such learning software can be customisable either by the student or teacher (sections 6.2.2 and 6.2.3.3), though in the case of VEs developed in the research presented here, the majority of customisations would be set by the teacher because self directed learning, as discussed in section 2.4.1, is difficult if not impossible for people with AS. There may well be some features though, not directly affecting learning goals or strategies that some students would be able to set themselves or, if given a set of instructions by a teacher (or given online), could set features themselves if using the VE at home. Whether help is on hand by a teacher or not, the VEs should contain scaffolding/agents to guide the user, inform when in difficulty and give available options, though also inform the teacher if help is required. The type of alerts for the teacher have to be thought about carefully and may differ for a teacher of ASD students, but in any case they should allow for intervention and problem solving (sections 6.2.3.3 and 6.2.4).

For software to handle the much varied and unstable features of an individualised learning experience with all the inbuilt scaffolding to aid the learner or monitor situations for the teacher requires open, flexible, interoperable architecture that can deal with change, using dynamic programs such as XML or in VEs a flexible modular approach (sections 6.2.3.4 and 6.2.4). It is advised that audio and video material within programs be kept to a minimum, as these are difficult to maintain change. However in teaching certain subjects and especially social skills to people with special needs there is a requirement for substantial amounts of this media. Another problem with most learning software is the ability to submit answers in natural language or for the system to cope with open questions (section 6.2.3.4). Improvements in technology such as voice synthesis and speech recognition will help overcome these problems in the long term while currently some of these issues could be addressed with a CVE where a combination of natural behaviour and system control can guide the learning, though with the teacher taking on more of the assessing role of the students social interactions with the software checking the students ‘physical’ interactions within the environment or choices made.

There has to be a supportive environment for the learning software, where it fits into the overall learning strategy and copes with Gagne et al’s (1992) nine events of instruction (sections 6.2.3.2 and 6.2.3.3). The software should be usable with the interface made as intuitive as possible. The interface may require some demonstration by the teacher though the actual learning scenarios should be attempted by the user at their own pace using trial and error though using inbuilt scaffolding to guide them and offering options when in difficulty to reduce frustration (section 6.2.3.2).

From these points discussed, recommendations can be drawn for desktop VEs to be capable of supporting individualised learning as follows;

1. Support Mass Customised Education
2. Tailor program either by student or teacher.

3. Contain scaffolding/agents to guide user, inform teacher, allow for intervention and problem solving.
4. Software requires open, flexible, interoperable architecture to deal with change.
5. Keep audio (speech) to a minimum or use voice synthesis/recognition.
6. Fits into overall learning strategy
7. Interface to be as intuitive as possible – may require demo, though user should try in scenarios. Use scaffolding to reduce errors, give options, reduce frustration.

The next phase of development for the VEs in the research discussed in this thesis should aim to address this need for individualisation by incorporating the feature into the constructed VEs from the start. It was recognised that teachers and autism professionals should be consulted to identify the key features of both the 'physical' model and the interactive features of the VE they deem most appropriate to have control over, to facilitate the learning experience. Therefore as a precursor to the development of new individualised VEs, it was decided to construct demonstration VEs as a tool to facilitate teacher's input to the design.

6.4 Demo VEs

6.4.1 Setup

The purpose of the demos was to quickly construct VEs that could be shown to autism professionals to illustrate the possibilities of individualising a scenario and how this could be achieved. This was considered a useful method for obtaining information from teachers as they could easily visualise what the designer is trying to explain and more easily see what could go wrong with the setup. The idea of practising the same core task in different contexts was deemed desirable for investigation, as teachers had mentioned previously that this helps promote generalisation. As queuing in the café and bus VEs already existed, then joining a queue in other contexts was seen as being the quickest one to demonstrate. Two new scenarios were constructed to demonstrate configuration options for the queuing task.

1. a post office involving the user having to walk around a cordoned area for the queue, before being called to a specific numbered window.

2. a bank where there is typically just a stand at the furthest point from the entrance which the user has to stand and wait for an available cashier.

The four queuing scenarios are listed on a menu for the user to choose and for the new scenarios in the bank and post office, the user could select some individualised features e.g. length of queue. The two new scenarios had the same interface as the bus and café VEs to maintain uniformity, though many features such as thought bubbles were not included as they were not required for the demo scenarios.

6.4.2 Post Office

The layout of the post office VE consists of a large room with post boxes, tables and stands for leaflets around some of the walls. Stands with belts form a snaking channel into which the queue for the cashier windows will go. There are five windows for the cashiers with a mixture of males and females occupying these positions. Above the windows are electronic displays, numbering each window, which are used to alert users which one is available (see Figure 6-2).

Figure 6-2: Layout of post office VE

The task for the user is to reach an available cashier, joining the queue first if need be. Set up options for the training facilitator include the length of the queue and which windows customers are standing at the beginning of the scenario. Working on this basis, there are seven possible different scenarios, these being;

1. No customers at windows, no queue.
2. Customers at all windows, no queue.
3. Customers at all windows, short queue.
4. Customers at all windows, long queue.
5. Some windows with customers, no queue.
6. Some windows with customers, short queue.
7. Some windows with customers, long queue.

The quickest way of programming something is not always the most efficient, especially in a small program. As the post office VE was needed quickly as a demo and would not be developed further, the code used in this VE followed the pattern of that which had been used in the café and bus VEs in that difficulty levels were used. While the user would not be aware of a difficulty level as such, the parameters chosen to individualise the VE effectively make the 7 levels mentioned above. Therefore a typical piece of code would have the structure as that in Figure 6-3 (shows the code written English, for actual code syntax, see Appendix E), where sections of code are carried out if the difficulty level is appropriate. For example, level 1 is for no queue or people at the windows and so the program just checks to see if the user goes up to the cashiers and does not check if they go inside a check group which envelopes where the queue will go as it does for other levels such as 3 and 6.

```
if (difficulty level = 1)
  {
    if (user is at any serving window)
    then <go to clerk serving customer sequence>
  }
if (difficulty level =5)
  {
    if (user is standing at a service window)
    {
      if (the clerk there is available)
        then <go to clerk serving customer sequence>
      else <tell the user to go to another window>
    }
  }
if (difficulty level = 3 OR difficulty level = 6)
  {
    if (the user joins end of queue)
      then <go to scenario in queue just behind 1 person>
    if (the user goes to a service window)
     then <tell the user they have to join the end of the queue>
  }
```

Figure 6-3: Algorithms for Post Office ‘level’ code.

Scenario set-up involves a few stages of option selections to be made by the training facilitator, illustrated in Figure 6-4. First of all they choose how many customers they want to stand at the cashier windows, *none*, *some* or *all*. If *none* is selected then the scenario will start with no people at the windows and no queue, effectively the easiest difficulty level. If *some* is selected then the training facilitator will be asked to select which windows they want the people to stand (though of course the program will not allow all the windows to be selected). Figure 6-5 shows the dialogue box with the numbered windows shown in a simple list to represent the actual windows in the VE. The training facilitator can place people according to scenarios they wish the student to encounter, e.g. place people near to where the user starts in case they wish to see how the student responds to having to walk past these people or if they place people farther away and leave an empty window near to where the student starts to try and entice them to go straight to the window rather than join the queue, if there is one (see Figure 6-6). If *some* or *all* of the windows are selected, then the training facilitator will then be asked to select the length of the queue they want waiting for the cashiers. Three choices are again offered here, *none*, *short* and *long*. While the channel the queue goes down (see Figure 6-6) effectively stops the user from pushing in to the middle of the queue, having a long queue is more of a visual barrier to whether it puts the student off having to wait. A short queue however might not be as noticeable and give the possibility of the user pushing straight to the front.

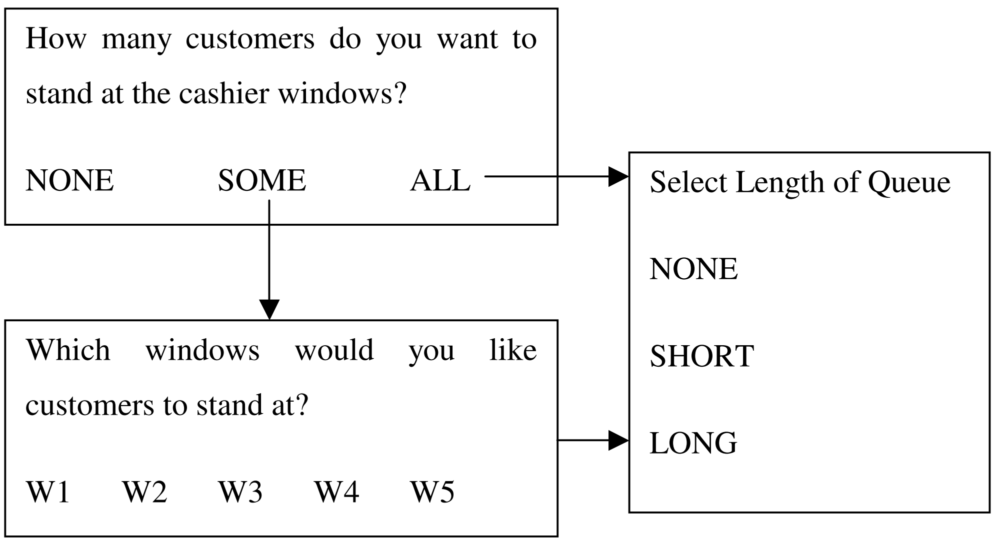


Figure 6-4: Post Office customisable options

Figure 6-5: Dialogue box to set up customer positions.

Figure 6-6: Empty windows with person still waiting in queue.

Once the scenario has been set up by the training facilitator, the student starts with a viewpoint in the post office facing the queue barriers and cashier windows. If there is no queue, then the student can go straight up to a cashier window (see Table 6-1 for queuing scenario options). If there is a queue then the user should join the end of the queue, which might mean them having to navigate around the potentially off-putting bend in the barriers. The user might also try and jump the queue by going straight to the front or by going up to an empty window. This might be just inappropriate behaviour or the user might see an empty window even if there is a queue. This could be because the cashier is busy and not ready to see another customer or the next person in the queue just has not got round to getting there yet. If the user falters here, then they are informed they have to join the queue first. If the user successfully joins the queue, then as the queue diminishes they have to navigate their viewpoint around to keep up with the last person in the queue. This feature might not be desirable in an actual learning VE if it was felt to be unnecessary work not associated with the main learning goals, but for the purpose of the demo (easier and quicker to program) it would suffice. Once the user is at the front of the queue, then they have to wait for an available window to be announced. A verbal prompt as well as visual feedback in the text box (see Figure 6-7) is given to the user and the numbered digital display above the available window in the VE flashes as another visual prompt. The user can then go to this window to complete the task.

Scenario	User Action	Permissible	VE Response	Next Action Solution
No queue	Goes straight to window	Yes	User served	___________
	Goes to queue area	Yes	Nothing happens	User must navigate to available window
Queue	Goes straight to any window (even empty ones)	No	User told to join queue.	User must navigate to end of queue
	Joins queue	Yes	Queue Diminishes	User must follow last person in queue until they are at front.
	Follows queue until at front	Yes	User told what window is available	User can go to window nominated though can also go to any other window that is available.

Table 6-1: Post office queue scenarios

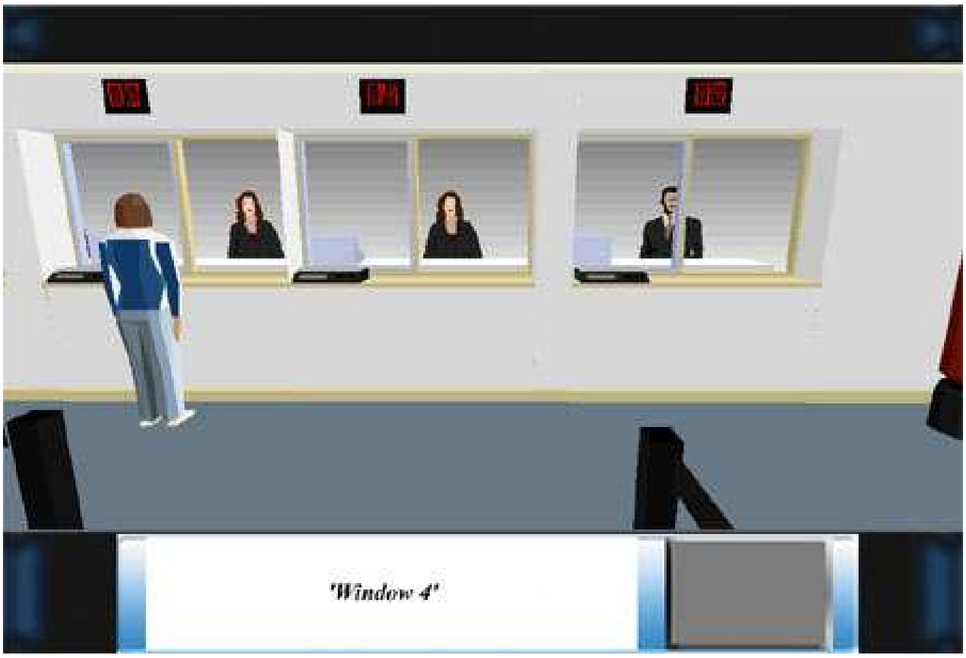


Figure 6-7: Announcement of available window

6.4.3 Bank

The layout of the bank VE consists of a large room with ATMs, tables, chairs, plants and stands for leaflets around some of the walls. Logos for the bank are displayed prominently around the room and these can be altered to the user's preference (see Figure 6-8). Cashiers are placed at three windows and can be selected to be male or female. A barrier parallel to the cashier windows forms a physical indicator of where to queue with a sign at the far end of the barrier showing that the queue starts from there. This is reflective of most banks, but in the different contexts produced for the learning programs it allows the user to possibly find it easier to join the back of a long queue, but might also make the user go straight to the nearest available window, rather than go past the windows and join the back of a small queue. The task for the user is again to reach an available cashier, joining the queue first if need be. To set up the different possible scenarios, the training facilitator is again asked a series of questions pertaining to the length of the queue and which windows people are standing at the beginning of the scenario. This time though the gender of the cashier can be selected (some people with AS have issues speaking to people of a certain gender) and also whether they are available. This latter point is to mimic the situation where a cashier is visible at a window, but they are busy with some other work and the position is closed.

Figure 6-8: Layout of bank VE

It became obvious that due to the number of changeable parameters that the number of potential different levels was becoming too cumbersome for the code to be handled in the same level based way as previously shown in the post office VE. Therefore the code was programmed in the following fashion where sections are activated depending on the value of parameters (e.g. length of queue, whether people at windows) after an event has occurred (users viewpoint is inside one of the check groups). The code (as shown in Figure 6-9) starts when the user has walked up to one of the cashiers windows and the program checks if there is no queue (qlength = 0, even if there was originally a queue, the parameter is set to zero once the queue has diminished and the user is first in line) and if so allows the program to continue (if there was a queue the user should join it and not go straight up to the cashier window) and checks the availability of the cashier (clerk[1]) or if another customer is already at the window (atwin[1]) before assigning an appropriate voice to the cashier depending on their gender. (for actual code syntax, please see Appendix E)

```
if (the user is at a cashier window)
 {
   if (qlength = 0)
   {
     if (clerk[1] is serving customers)
     {
       <set voice of cashier to appropriate gender>
       if (atwin[1] = 1 *somebody is already at the window*)
       then <tell user they have to go to another cashier as they are already serving someone>
       else
         <go to serve customer sequence>
     }
     if (clerk[1] is unavailable)
     {
       <set voice of cashier to appropriate gender>
       if (atwin[1] = 1 *somebody is already at the window*)
       then <tell user they have to go to another cashier as they are already serving someone>
     }
   }
   else
   {
    <tell the user they have to join the end of the queue>
   }
 }
```

Figure 6-9: Algorithm for serving customer in bank VE

The VE starts with a series of questions for the training facilitator to set the scenario up for the student (see Figure 6-10). A choice of four banks is given (again just to show the possibilities of individualisation – many more would be required in an actual application), the NatWest, HSBC, Lloyds TSB and the Halifax, to make the surroundings familiar to the individual user. The length of the queue is then chosen with again the options being *none*, *short* and *long*. A dialogue box then appears asking which windows, cashiers and customers should stand at (see Figure 6-11), though again the program will not allow a customer to be placed at an unavailable window. The dialogue box consists of a series of list menus and selection boxes, displayed in a format mimicking the layout of the cashier windows in the bank. For each position the gender of the cashier can be selected, if indeed a cashier is positioned there. The availability of the cashier with respect to dealing with customers can be selected and also whether there is already a customer at the window.

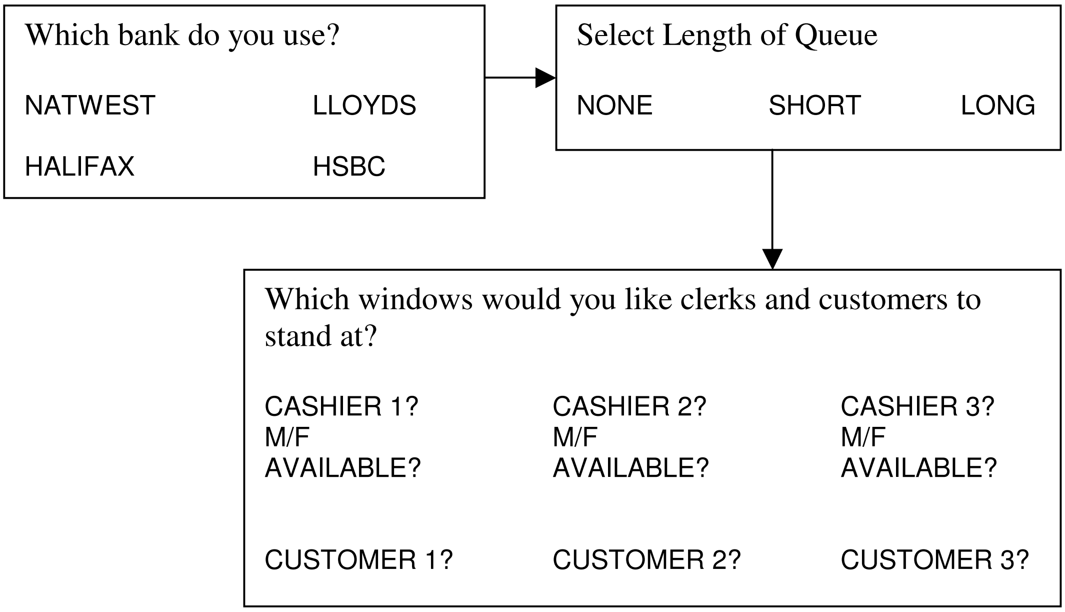


Figure 6-10: Bank customisable options

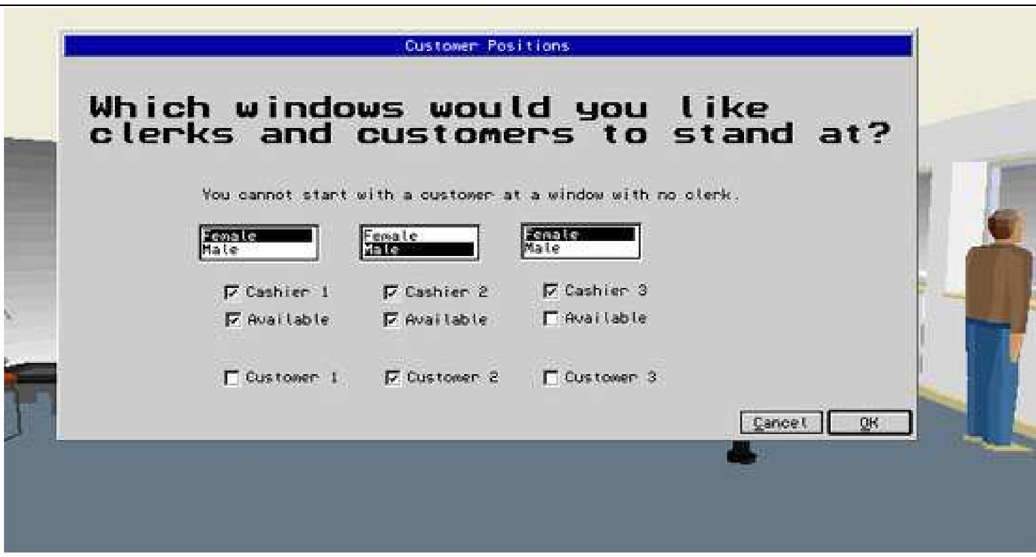


Figure 6-11: Dialogue box for cashier and customer settings.

Once the training facilitator has set up the scenario, the user's viewpoint in the VE is the same as in the post office facing towards both the queue and windows. The user could go straight up to a window if there is no queue, but be told they have to join the queue if there is. If there is a queue, the user could also join it successfully or try and push into the middle of it somewhere. If the latter then again the person who had been pushed in front will tell them off and ask them to join the back of the queue. Having joined the queue, the user moves to the front where they are asked to wait for an available window to be called with a prompt given verbally in a voice relating to the gender of the available cashier with a text prompt also given. The user can then approach this window or any other cashier who has become available. Some cashiers are unavailable and a sign is displayed at the window, telling people the position is closed (Figure 6-12). If the user approaches one of the unavailable windows, they are instructed to try another one (see Table 6-2 for queuing scenario options).

Figure 6-12: Unavailable cashier and instructions.

Scenario	User Action	Permissible	VE Response	Next Action Solution
No queue (or when user at front of queue)	Goes straight to available cashier	Yes	User served	____________
	Goes straight to unavailable cashier (position closed)	No	User told to go to available cashier	User must navigate to available cashier
	Goes to queue area or empty window	Yes	Nothing happens	User must navigate to available window
Queue	Goes straight to any window (even empty ones)	No	User told to join queue.	User must navigate to end of queue
	Joins queue	Yes	Queue Diminishes	User must follow last person in queue until they are at front.
	Follows queue until at front	Yes	User told to go to available window	User goes to any window that is available.

Table 6-2: Bank queue scenarios

6.5 Demo VE Evaluation

6.5.1 Method

Three local groups (Sutherland House - Nottingham, Leicestershire Autism Outreach – Coalville and Derbyshire Autistic Services Group - Ripley) interested in the learning VEs and who had attended the final review and launch of the bus and café VEs were asked to review the individualisation demos and to provide initial feedback on the additional features presented and how future development should proceed. A short questionnaire was applied to capture their opinion on specific aspects of the demo VEs and can be found in Appendix F. The questionnaire consists of a number of open ended questions as well as Yes/No answers to gather information about what the reviewers thought about having the same task in different contexts, what they thought of individualisation and what should be individualised, and what other features would be an issue to people with autism that they felt had not been addressed by the café or bus VEs. The questionnaire formed the basis of a semi-structured interview whereby reviewers provided general comments as they 'walked through' the demos, but with the author prompting responses to specific questions of interest. The questions asked were grouped into three areas and were as follows;

Task in context

- Is having queues in different contexts useful?
- What other contexts for queuing would be useful?
- What other situations within queuing would be useful?

Individualisation

- Do you think individualising learning software for the user is useful?
- What other individualised features in queuing for bank or post office (bus or café) would be useful?
- What other situations apart from queuing, would, in different contexts, be useful with regards to social skills?
- What other areas in social skills would be useful to individualise?
- What other issues are important to people with autism/AS? (e.g. colour, noise, people)

Features to use

- Select type of queue – then context?
- Select age, sex, type of person (fidgety, talks loud etc), height, appearance etc?
- Save profiles for individual users so they can be loaded quickly next time?

6.5.2 Procedure

The three groups were visited and the VEs demonstrated on a Novatech P3 700MHz, 64Mb RAM, 14" laptop with a joystick and mouse connected. Participants included two reviewers in each group who were free to discuss together their opinions. Initially the bus and café VEs were shown as a reminder of what they did and how they worked, especially with regards to being 'level' operated as well as showing the queuing procedures in both. The post office was shown next as its individualisation interface was not as detailed as the bank scenario, so that a gradual progression of how individualisation could be clearly demonstrated. The author took the reviewers through all the different scenarios and possible parameter changes explaining each element as the task progressed. Reviewers were free to comment on the VEs as they were being demonstrated with a colleague taking down notes of these comments. After the demonstrations, the author asked the reviewers the questions listed earlier (unless a specific question had already been answered in the course of the demonstration through comments made by the reviewers) in the context of a semi-structured interview, noting down their responses and additional comments.

6.5.3 Results

	REVIEW GROUP		
	R1	**R2**	**R3**
Q1 – Is having queues in different contexts useful?	Yes, but don't over complicate for teacher by having too many.	Yes	Yes
Q2 - What other contexts for queuing would be useful?	♣ supermarket checkout - have a waiting element in queue as they will want to eat what's in their trolley. ♣ cinema – have different types of queues. ♣ 10 pin bowling – more the issue of knowing what shoe size to get rather than the queue, apart from they might hold it up.	♣ corner shop, ♣ cinema, ♣ waiting in general.	♣ corner shop ♣ bowling ♣ cinema ♣ swimming pool -useful for dealing with issues such as nakedness, personal space etc.
Q3 - What other situations within queuing would be useful?	♣ children in queue ♣ parents with pushchairs ♣ busy people with bags ♣ people coughing ♣ race of people in queue ♣ mobile phones going off.	♣ Unexpected behaviour, kids rushing off and coming back.	

Table 6-3: Demo Review Results - Task in Context

	R1	R2	R3
Q1 – Do you think individualising learning software for the user is useful?	Absolutely	Yes, very much so – current applications definitely require more flexibility.	Yes, though scenarios have to be suitable – we deal with a younger age group so banks and post offices not relevant.
Q2 - What other individualised features in queuing for bank or post office (bus or café) would be useful?	•Type of person in queue (race, height, sex, personality etc)	•Physical layout of environment (where are cashiers in relation to entrances etc). •Length of time you have to wait in queue.	N/A for younger age group.
Q3 - What other situations apart from queuing, would, in different contexts, be useful with regards to social skills?	•Waiting in general •asking for help.	•Interactions with opposite sex, •safe behaviour (whether someone is a threat to their safety), •asking for help, •speaking out of turn.	•Giving and receiving things, saying please and thank you. •Social games such as at parties.
Q4 - What other areas in social skills would be useful to individualise?	•Role that the user takes – see other peoples point of view.	•Going to airport - lots of queuing and waiting, procedures to be followed and unexpected things like delays. •Attitudes to opposite sex (particularly males attitudes to women – there seems to be a worryingly growing number of incidents of sexist comments and behaviour amongst autistic males.	•What they say, peoples responses, e.g. angry •The role that user takes, e.g. being the person in the queue instead who is then pushed in front by somebody, to get other peoples perspectives on the same situation.
Q5 - What other issues are important to people with autism/AS? (e.g. colour, noise, people)	•Unexpected noises and actions, •facial furniture (nose rings etc), •going from light to dark and vice versa (e.g. in a cinema), •different types of people (e.g. young excitable people in a cinema. •People pointing and staring at them.	•Humour, lack of understanding if someone is joking with them. •Ages of people, especially if much older – saying things like you'll be dead soon. •Inappropriate contact – licking someone's face. •Turn taking, being a part of a team.	•Disappointments, not getting what they expected - based on poor generalisation and prediction. •Emotions - especially anger management. •Personal space.

Table 6-4: Demo Review Results - Individualisation

	R1	R2	R3
Q1 – Select type of queue – then context?	Yes	Yes, but has to make sense, though that would be up to teacher.	Yes
Q2 - Select age, sex, type of person (fidgety, talks loud etc), height, appearance etc?	Yes, and race.	Race, girls in short skirts.	Yes to all
Q3 - Save profiles for individual users so they can be loaded quickly next time?	Yes	Yes	Yes, must be easy to set up - almost plug and play, technical difficulties might cause barriers to use.

Table 6-5: Demo Review Results - Features

6.5.4 Discussion of Results

6.5.4.1 Task in context

All the reviewers agreed that it was useful to have different situations in which people with AS could practice queuing to help show how the same task could be approached differently in different contexts. They were able to think of a number of other contexts for queuing which also got them thinking about other scenarios that people with AS might find difficult in a social situation, such as going to a supermarket, corner shop, cinema, swimming pool etc. Other situations within queuing (other than people pushing in) which the reviewers felt might be an issue were unexpected events such as children running about (and probably making a noise) or other busy people and noises such as coughing or mobiles ringing as well as cumbersome objects such as prams and shopping bags which might get in their way.

6.5.4.2 Individualisation

The reviewers all agreed that individualisation of learning VEs was not only useful, but a much needed requirement for teaching people with autism, though scenarios would of course have to be relevant to the user population (in terms of age, gender and ability). While specific scenarios such as what happens when a user goes to an airport with all the different social interactions that take place were suggested, it was apparent that the issues relating to them such as queuing, waiting, procedures, interactions with opposite sex etc, can be seen as general social skills that relate to many situations and are therefore key issues to be incorporated within a social skills learning VE. Other such general issues are unexpected events such as noises, unusual (to the person with AS) physical features, emotions and lighting effects. Inappropriate contact, turn taking, being part of a team and lack of understanding of humour as well as dealing with disappointments were also seen to be crucial factors that need to be addressed within social skills learning. Seeing things from another persons perspective was also seen as being a helpful feature that VEs could accommodate, especially taking into account the ASD characteristic of a lack of ability in dealing with generalisation or empathy.

6.5.4.3 Features

All the reviewers agreed about the features that should be individualised within a scenario and that being able to save the setting and parameters of the VE for each user would be extremely helpful. This would allow each student to start where they left off each time they use the VE and allow an unbroken progression of learning as well as save time for the teachers in setting up the scenarios at the beginning of a teaching session, though there would be a requirement for more preparation work before any students begun using the system.

6.6 Conclusions

Learning Task	Contexts	Issues for people with ASDs	Controlled Features
•Queuing & Waiting •Asking for help •Interactions with opposite sex - sexist comments etc •Safe behaviour – recognising if someone is being a threat •Social games •Giving/Receiving – when to say please and thank you.	•Corner Shop •Supermarket •Cinema •Bowling •Swimming Baths •Airport	•Unexpected events - coping with change •Disappointments – not getting what they want •Dealing with emotion – especially anger, facial expressions •Different people – race, height, age, sex, piercings, clothes, personality •Turn taking – being part of a team •Humour – is someone joking with them. •Inappropriate contact	•Role that user takes •Physical layout •People •Length of time to wait •Saving user profiles

Table 6-6: Summary of Demo Review Findings

From the findings in section 6.5, individualised learning VEs for social skills training were seen as being very useful and definitely worth further investigation. The most useful information obtained was about the form that such customisable VEs could take in terms of their content. Table 6-6 collates the findings into four areas;

1. the principle learning task that the VE should cover
2. the context in which this task could be set
3. issues for people with ASDs that transcend whatever task they are doing
4. elements or attributes of VEs that could be controlled or varied to offer a user a more effective learning experience

While the last column looks at features that can be controlled and modified by being part of an individualised learning VE, the other three columns list elements that can also be controlled by whether they are presented to the user in the first place. The first two columns (Learning Task and Context) add information to that already discussed in the identification of requirements (section 4.2) when learning objectives were first explored at the beginning of the AS project. The last two columns (Issues for people with ASDs and Controlled Features) contain the information that is really important to an individualised learning VE as these issues are the ones that can vary significantly between one user and the next. Also the ability of VEs to control what the user experiences in different ways is an important attribute of that technology. Specifically, VR/VE technology are good for supporting social skills learning as the layout of the environment can be controlled, scenarios can be modified to suit each user and the context of the learning scenario can also be modified easily. Drawbacks are that the current state of the technology does not represent facial expressions or other 'body language' very well, important issues for social interaction. This includes emotional responses, seen as being quite complex for the program to handle and would be better handled (especially anger management) by teachers after a scenario in the VE set the scene and situation for these matters to be addressed on a personal level with the student. The learning tasks incorporated into a VE will largely depend on time and the chosen context, though as many as possible should be included. Therefore in the next stage of VE development, possible issues that can be dealt with could be;

- Unexpected events
- Disappointments
- Different people
- Turn taking
- Inappropriate contact

The features of VEs that could be utilised would be;

- Role that the user takes
- Controlling physical layout and people
- Length of time to wait (if in a queue)
- Saving user profiles

6.7 Summary

This chapter has discussed the need for individualised learning in general and how current technology can facilitate this. Flexible technology alone cannot accommodate this learning paradigm and a successful individualised learning VE must have a supportive environment in which it is used, being incorporated into lessons, which include other teaching methods and maintains the important role of the teacher. This is particularly important for people with AS who require the support that only a teacher who knows them well can provide. There are few learning applications available that can be individualised with most of these being broad based curriculum tools for mainstream education and certainly none for people with autism. Recommendations for the design of a customisable learning VE were summarised from the literature and from this some demonstration VEs were built were built to show some basic features of individualised VEs which looked at a similar task in different contexts, to take to autism professionals for expert review. From these reviews, recommendations for design features of individualised learning VEs for people with AS were made.

Chapter 7. Individualised VE

7.1 Introduction

Review of the VEs developed during the AS interactive project to support teaching of social skills to users with AS found them to be too rigid and constrained to cater for the variety of individual teaching requirements amongst this user group (see section 5.8). Chapter 6 examined the value of individualised learning software and reviewed how VEs could be constructed to facilitate individualised learning of social skills for users with AS. Demonstration VEs set in a post office and bank with a small number of individualised features was shown to experts in the autism field to facilitate the generation of ideas for a fully working customisable VE.

This chapter discusses the development of an individualised prototype café VE, including additional new scenarios as well as customisable options of features which existed in the level based café VE. A prototype interface for customising the layout and choosing which features of the learning scenario the student will experience is shown, detailing every feature that the teacher or training facilitator has control over. The overall thinking behind the structure of the program code and how it evolved along with the VEs to find an effective way of developing an individualised rather than level based learning VE is also discussed.

The individualised café VE was then reviewed by experts, commenting on the customisable features, new scenarios, anything that could be added and whether this approach was more suited to students with AS. This feedback is detailed in this chapter, collating the experts review on how the individualised VE compares with the level based café (reviewed in sections 4.6 and 5.6), their opinions on the individualised features of the VE, the additional scenarios added and the potential for future development of learning VEs for people with autism.

7.2 Individualised Café

7.2.1 Proposed changes and development.

Research discussed in the previous chapter allowed the further development of the AS learning VEs to accommodate the individualised learning paradigm as well as incorporate the additional features and learning scenarios suggested by reviewers. Features felt to be relevant for individualised VEs by autism professionals could be developed within a prototype VE to more accurately gauge if a correct path was being taken with regard to adaptable VEs for teaching social skills to people with autism and what new issues would arise from this new paradigm. By further developing the level based VEs into individualised programs, there could then be a comparison between this new design methodology with what had gone before previously. One individualised scenario was initially developed so that it could be reviewed to have feedback flowing back into the design loop so future scenarios could be developed more quickly and effectively to a standard that could be tested in user trials.

The new VE would be based on either the bus or café and a number of the design recommendations reviewed in section 6.6. It was hoped to try and cover as many of these as possible and to try and include elements from across three design recommendation areas (Learning Tasks, Issues for People with AS and Controlled Features – see Table 6-6), though not including locations as they were already determined by reviewers and are not required for initial testing. Not all recommendations could be incorporated into the next stage of development. Table 7-1 presents a summary of VE design features and options for individualisation with reasons for the design decisions also given.

VE Feature and Individualised Option Requested	Design Decision	Reason
Scenario Context	Café VE	Already exists, evaluation of level based café for comparison.
Learning Task	Queuing and waiting Interactions with opposite sex Asking for help	Fits in with overall task or already part of the café VE.
Unexpected Events	Yes	Important issue not previously dealt with.
Dealing with disappointment	Yes	Important issue not previously dealt with.
Appearance of Characters	Mix of genders, races and clothes.	Already built.
Turn Taking	No	Does not fit in with tasks in café.
Inappropriate Contact	No	Difficult to replicate accurately in a VE, especially Superscape programs that use bounding cuboids for collision detection rather than facet collision detection.
Modify Layout	Yes – Change position of tables, length of queue, starting position of user	Relatively straightforward to implement in café by modifying the code that randomly sets positions of tables and initial position of user. Code that alters queue length and resultant scenarios already exist.
Modify Appearance of Characters	Not to be included	Time constraints, good mix already available, easy to visualise how this would work.
Role the user takes	Seeing same scenario from different perspective – being pushed in front by other person in queue, being asked by other person if they can join user at table	Fit in with existing scenarios, reinforce appropriate behaviour.
Length of time to wait	Yes – adjust time user has to wait (in seconds) in queue to get food	Simple to add to existing scenario.
Saving user profiles	No	Time constraints, would take a long time to program something that was seen as relatively easy to visualise and therefore comment on – seen as important though – to be looked into.

Table 7-1: Individualised VE Design Specification

In addition to the recommendations for an individualised VE provided by the expert review (section 6.6), consideration was also given to the general principles of individualised learning software (described in section 6.3). A summary of how the café VE would support these principles is given below:

1. Support Mass Customised Education – The café VE would eventually be part of a general program for teaching social skills to a whole class, but be customisable to individual student's needs.

2. Tailor program either by student or teacher. – The VE would be set up by a teacher beforehand.

3. Contain scaffolding/agents to guide user, inform teacher, allow for intervention and problem solving. – Automatic viewpoints, invisible walls and a dynamic interface as developed for the level based café VE as well as help given to the user on what do to if there is a problem should meet this need. A scenario where the user asks an employee for help who could also be on hand to give help automatically to the user may be a more appropriate method of distilling help than an invisible agent which manifests itself in text and audio feedback.

4. Software requires open, flexible, interoperable architecture to deal with change. – Modulated code as described in section 7.3 will allow for change within parameters of the café VE, with additional scenarios being capable of being added to the overall modulated learning program.

5. Keep audio (speech) to a minimum or use voice synthesis/recognition. – Currently the student will select questions or responses as before in the level based café VE from a list and therefore audio files should remain constant, though having a big enough library of files to begin with may offset the requirement for future changes. This area could be more problematic if teachers want complete control over communication by typing in responses themselves.

6. Fits into overall learning strategy. – The original level based café VE has been used by teachers in schools as well as discussions on the topic of learning (finding a place to sit in social settings of a bus or café) before taking students out to try real life situations, so it is possible for a strategy that utilises the VEs for teaching the students.

The new programs being developed are designed to be used as an aid to lessons that already occur and not be the lesson in themselves.

7. Interface to be as intuitive as possible – The interface will be recognisable to students who had used the level based café VE. Even if not, the old interface was designed in an iterative process with the input of users to create an interface that used recognisable icons, common interaction metaphors that are built up with the aid of scaffolding. More help may be required to be offered by the program by indicating the correct icons or objects to select if the user is struggling.

7.2.2 Individualised Features

There are a number of customisable elements which can be changed to alter the look and feel of the café. Apart from the random colourings of the floor and people in the queue, the teacher can select whether there are people standing about or walking around the café, though it would make more sense to do this if the tables were relatively busy. The tables themselves could have one of three settings, empty, part filled or full. To make things easier in terms of programming and perhaps the choice for the teachers, the fullest the café could be would be similar to level 4 of the initial VE where all tables have at least somebody sitting at them, but with available seats on some. In other words there will be no more people added to the tables for the individualised VE and therefore while all tables will be able to be empty or part filled, only some will have the capability to be made completely full. This should not affect the learning task, as ultimately the user has to find a seat and not worry about full tables. The position of each table can also be set by the teacher though they must occupy one of the initial six table positions. This will not only alter the look of the environment due to there being different styles of tables and chairs, but also means the teacher has control over where the empty and part filled tables are positioned it they wish to make it more easy or difficult for the user to find a seat.

The position the user starts the task can also be selected, from near one of the three walls not occupied by the bar and food counter, with their viewpoint rotated to face the centre of the room. This can be used to disorientate the user slightly so they have to look for the queue to the counter rather than just know straight away where to navigate to. The background noise heard in level 4 of the old café VE can now be selected to be heard at any time, though again there would be little point in having this when the café was completely empty and so the program should check for this.

As in the post office and bank VEs, the length of the queue (none, short, long) can be selected, but in addition to this the time the user has to wait before the queue starts to go down can be chosen. This of course is to try and test the patience of the user, to see if they will stay in the queue or wander off and to replicate what might happen in the real world.

The gender of the person serving at the counter can be chosen in case the user has issues dealing with the opposite sex. Similarly, when selecting which tables are going to be part filled or full, there will be an indication of whether that table is all male, all female or mixed so that selections and positions can be made accordingly to allow interaction at a partly filled table with a particular group.

The level of scaffolding can be selected so that no matter what the supposed difficulty of the scenario, guidance can be added or taken away as the teacher sees fit to suit the needs of the user at a particular time.

A new feature which is always available and does not need to be selected, is an ‘asking for help’ feature. Basically, once the user has paid for their food, then when they approach the cashier again, the speech bubble icon appears, but this time there is a question mark on it (see Figure 7-1). By clicking on this, the user brings up a series of two responses relating to their overall task, these being;

- Where can I sit?
- I don’t think there is anywhere to sit!

The user will then be told that there is in fact an empty table they could sit at or that they should ask someone if they can sit beside them.

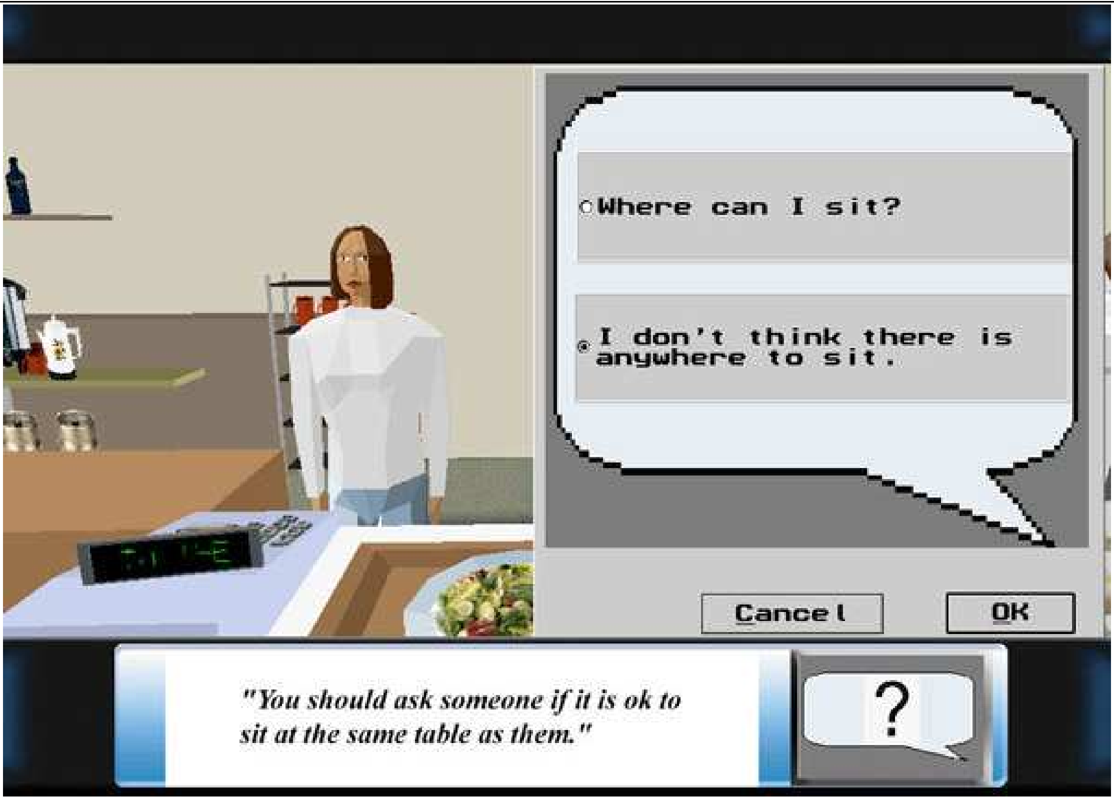


Figure 7-1: Asking for help in the café.

Many of the elements discussed above for individualisation all centre around features that already existed in the previous café VE, so effectively the previous four levels of difficulty could be set up by the teacher with the right selections, but feedback from the teachers indicated that there were a couple of features in particular that would be beneficial to add, those being role play and dealing with unexpected events, which are discussed in the next section.

7.2.3 Unexpected Event and Role Play Scenarios

Unexpected events, which also encompass dealing with disappointment, are seen as important social skill issues for people with ASDs and were therefore seen as an obvious omission from the previous bus and café VEs. Unexpected events could involve people behaving strangely or doing things they shouldn't which could involve children who can always be expected to act their age and do things like running in and out of the queue to their parents. An unexpected event could also involve sudden noises such as alarms, which might startle the user. Human motion in Superscape VRT is not ideal for this situation so an audible event was chosen as an example of this type with somebody's mobile phone ringing. If this event is selected and there is also a long queue, then when the user joins the queue and has waited the length of time specified by the teacher, the mobile will ring and the person will eventually answer it and have a conversation (of which the user only hears the one side of). Once the conversation has ended, the user is moved towards the food counter to continue with the overall task.

When at the food counter there is the opportunity for the user to experience disappointment as the teacher has control over which food on the menu is available. Therefore, if the user has a favourite food that they always order, then this could be omitted from the menu and they would have to learn what to do in this situation. If the user selects a menu option that is not available then the person serving informs them of this. If the user continues to select the unavailable food option then they will be informed to make another choice, though this could be tied in to the level of scaffolding given.

Role play options are meant so that the user can experience some of the scenarios in the VE from the other persons point of view to hopefully allow them to appreciate the reaction people would have if they behaved in a similar manner. There are two situations in the café VE that allow the user these experiences, one, being pushed in front of in the queue, the other, having somebody come up to you when you have sat down to ask if they can join you. If the option is selected, then when the user joins the queue, another person walks from the side and into the queue in front of them. Written and verbal feedback is given to the user about this event and the speech bubble icon appears on the interface. The user clicks on the icon and the familiar dialogue box with 3 responses appears, two of them appropriate to the situation, one of them inappropriate. The user must click on an appropriate response to tell the person off for pushing in and if so the person apologizes and moves to the back of the queue. If an inappropriate response is chosen then the user is ignored.

The user can also experience what it feels like when they are asked if it is ok to be joined at the table they are sitting at by another person. Once the user has successfully found a seat and the option has been selected, then another person will approach the table and ask if it is ok to sit with them. A dialogue box then appears with 4 responses for the user to choose from;

- No, someone is sitting there.
- There is a free table over there.
- Yes, that seat is free.
- There isn't a free seat here.

The user can either say that the seat is taken (by somebody else, which might be a lie as they just don't want to be bothered, but this is something which would be discussed with the teacher) or that they can indeed sit with them. If the table they are at has no free seats then they should remind the other person of this by saying so or could equally say that someone is sitting there. If there had been several empty tables to begin with then there will still be others available once the user has sat down and can tell the other person to sit there. All these options would probably require discussion with the teacher as to what additional responses could be given in different situations and the user may need to be taught to look around to see if there are other spare tables available. If the user selects a response that is not true, e.g. telling the other person that there is a free table elsewhere when there is not, then written and verbal feedback will show this to be incorrect and inform the user to try something else.

7.2.4 Interface

When the individualised café VE is initiated, the input screen appears for the teacher to set up the scenario (see Figure 7-2). This interface was developed as a prototype and is by no means a finished product, being used to show the teachers the kind of control they can have via different input methods, from drop down selection menus, check boxes and typed numerical values. The main picture on the interface shows an overhead view of the café (see Figure 7-3) annotated to show the 3 possible starting positions, A, B and C and tables 1 to 6 in their respective initial positions, e.g. the red table is table 1 and is in position 1 to start with.

Figure 7-2: Individualised Setup Interface

Figure 7-3: Overhead plan for café layout.

Underneath the overhead view is the section for setting up the layout of the café (see Figure 7-4). Tables 1 to 6, as shown in the main picture, are listed down the left hand side. Beside this are menus where the table can be selected to be empty, part filled or in some cases full. Whether the tables are all male, female or mixed is indicated and there are tables in each of these categories that can have all 3 availability settings, which allows the teacher to control whether the user can interact with men, women or both. The right hand side of this section has the positions of the tables, which relate to the numbered positions on the main picture. Therefore the teacher can either make a table that they wish the user to interact with prominent, near the cashier or hidden further away in a corner. At the bottom is start position selector which relates to the 3 positions A, B and C so that the café can have a different initial feel to it and so that the teacher if they wish can position the user and tables in a way which makes it difficult for the user to see a free seat until after they have got their food and are looking around or alternatively has an available seat visible to the user straight away before they even get to the queue. The colour of the position selector highlight is red to associate it with the red letters on the main picture and likewise the table input highlight is blue to link them with the blue numbers on the main picture.

Figure 7-4: Table setup interface.

Figure 7-5 shows where the settings for the queue, server and scaffolding can be made. The length of queue can be chosen from a menu list and the time (in seconds) that the user has to wait in the queue before the scenario continues can also be set.

The gender of the person serving food can be selected from a list so that again the user can be made to interact with somebody of a particular sex. The scaffolding level is where the teacher decides on the level of guidance the VE should provide the student, from highlighting areas in the VE that require the user to navigate to or interact with, to additional onscreen instructions or options. For the purpose of this demonstrator only two levels (effectively on and off) can be selected, though in later additions, teacher input would be necessary to help grade the amount of help given on different levels and perhaps have control over the different scaffolding elements e.g. have additional instructions, but no highlighted panels or icons.

The section shown in Figure 7-6 has a series of checkboxes for the simple choice of having the situations listed occurring in the VE or not. The six elements are effectively three groups of two, the first two relating to the appearance of the café with people standing or walking. The next two relating to seeing a situation from another point of view, whether this is being pushed in front in the queue or being asked if they can be joined at a table by somebody else. The last two elements are noise related, with either there being background noise or the unexpected event of somebody's mobile ringing.

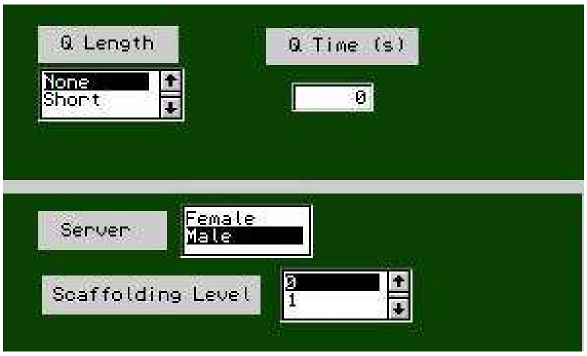


Figure 7-5: Queuing, scaffolding and server setup.

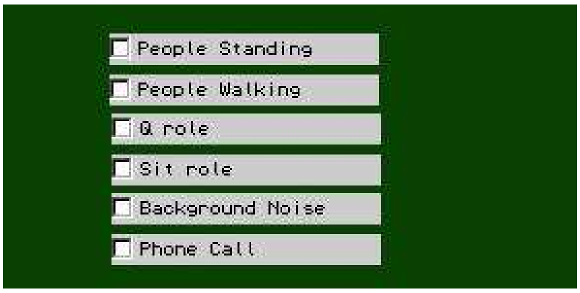


Figure 7-6: Event Checkbox

The last part of the interface (see Figure 7-7) simply shows the menu options with check boxes to be selected or not depending on what type of food the teacher wants the user to get or whether they want them to deal with disappointment with there not being the user's favourite food.

Figure 7-7: Menu selection.

7.3 Code Structure

As mentioned in section 6.4.3, the code for an individualised VE must be structured so that individual parameters are what trigger events in the VE rather than a pre-defined level activating a series of events. This means that the code for the VE is broken up into small groups which are each responsible for an event e.g. activating and running the pushing in queue scenario and these groups are triggered by a specific variable relating to that piece of code rather than an overall level variable which could trigger numerous events e.g. length of queue, busyness of café and background noise. This way of arranging the code is based on the Object Orientated method of programming.

An object is a program module that encapsulates some portion of a program's characteristics and behaviour. Objects can communicate with each other by sending and receiving images. This idea of interacting objects is the basic metaphor of object orientated programming. It is a very natural metaphor that conforms to the way we do things and solve problems in our everyday world. Object orientation follows the divide and conquer principle, where a program is divided into a set of well defined subtasks and then to design an object to solve each of the subtasks. Dividing a task up in this way reduces the amount of information that each object needs to know in order to perform its job. This simplifies each task and increases the chances that it will be performed correctly (Morelli, 2000).

Superscape VRT is set up in such a way that lends itself naturally to this type of programming with separate pieces of code attached to objects within the VE, e.g. code controlling the movement of a car attached to the car object, with separate pieces of code able to communicate with each other to form a web of code which controls the whole environment. In many ways this is easier to handle and visualise for the programmer rather than there being imaginary objects in a non visual programming structure such as a java or C++ program. A disadvantage is that it can become quite easy to lose track of where all the separate pieces of code within the VE are and the programmer has to be aware of this at the beginning of a project and organise the program efficiently. Another disadvantage to the pure form of object orientated programming is that it can be an overly complicated solution if the problem is simple i.e. it could take a much longer time to program in this way for relatively straight forward functions. There is therefore a trade off in developing the VEs over the level of subtasks required to make the VE as scalable (the ability to expand scenarios rather than allow greater numbers of people to use the system) as possible and the time available to program these subtasks.

The individualised café VE, just like the original café and bus VEs has most of their code split into boxes, which are placed outside the main viewing area of the environment (see Figure 7-8). Therefore, the original bus and café VEs already had the basic structure, which allowed them to be scalable (flexible) and be transferred from a level based program to a parameter based one. The original VEs code was split for means of organisation and the communication between the pieces of code was largely through the different difficulty levels as this was how the learning scenarios were set out. It was good practice therefore that the author's methods of programming the original café VE allowed for a relatively straightforward modification to the unanticipated individualised VE, which shows the importance of having a scalable structure in environments which are always likely to be modified over time.

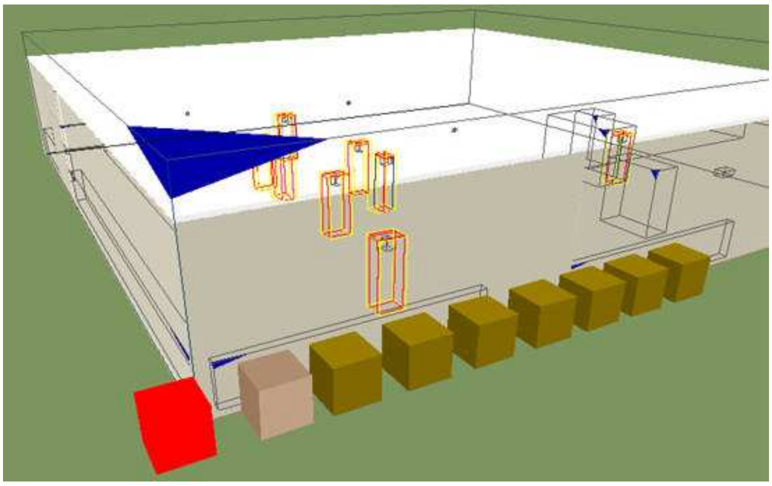


Figure 7-8: Code objects outside café.

The selections that the teacher makes in the setup screen assigns a value to a specific part of the Buffer which is the data input storage area for VRT. Variables in the code are then assigned values from the Buffer values in the form;

supvar[n]=Buffer[n];

where *n* is a specific variable (from a range of 28) in the array *supvar*. These variables being

0-start position
1-empty,part,full table 1,
2- ditto table 2,
3- ditto table 3,
4- ditto table 4,
5- ditto table 5,
6- ditto table 6,
7-12 positions of tables,
13-queue length,
14-queue time,
15-server gender,
16-scaffold level,
17-people standing,
18-people walking,
19-queue role,
20-sit role,
21-burger, 22-pizza, 23-curry,24-salad, 25-pasta

26-background noise,
27-phone conversation

The code for this along with the code for the new scenarios (unexpected events and role play) can be seen in Appendix G.

Apart from the new scenarios and obtaining the input data from the teacher, most of the code in the cafe just had to have alterations in the controlling variable. For instance, the code shown below is from the original café which gave a verbal and text prompt to the user once they had reached a table about what their options were. So if the difficulty level is 1, then all the tables would be empty and a specific prompt about either sitting down or moving to another table. If the difficulty level is 2 and the user is at a table with people then they are told they can speak to them. If the difficulty level is not 1 then the speech bubble icon appears to be used if required.

```
if (flag==99 || flag==2 && getvp==3)
{
  if ('codecube[1203]'.difflev==1)
  {
    instr (3)=86;
    waitf;
    handle=sound (9, 64, 127, 0);
    while (sound? (handle))
      waitf;
  }
  if ('codecube[1203]'.difflev==2 && instr (3)==2)
  {
    waitf;
    instr (3)=87;
    waitf;
    handle=sound (10, 64, 127, 0);
    while (sound? (handle))
      waitf;
  }
  if ('codecube[1203]'.difflev!=1)
    instr (2)=1;
  actchild ('tablegroup1', 0);
  actchild ('tablegroup2', 0);
  actchild ('tablegroup3', 0);
  actchild ('tablegroup4', 0);
  actchild ('tablegroup5', 0);
  actchild ('tablegroup2[112]', 0);
  flag=2;
}
```

The following code now shows the modified version for the individualised café. As can be seen, the only changes are replacing the *difflev* varaiable with specific or a combination of variables relating to the amount of help given (*scaflev*) and how busy a table is (*avail[seats]*).

```
if (flag==99 || flag==2 && getvp==3)
{
  if ('codecube[1063]'.scaflev==1 && avail[seats]==4)
  {
    instr (3)=86;
    waitf;
    handle=sound (9, 64, 127, 0);
    while (sound? (handle))
      waitf;
  }
  if ('codecube[1063]'.scaflev==1 && instr (3)==2)
  {
    waitf;
    instr (3)=87;
    waitf;
    handle=sound (10, 64, 127, 0);
    while (sound? (handle))
      waitf;
  }
  if (avail[seats]!=4)
    instr (2)=1;
  actchild ('tablegroup1', 0);
  actchild ('tablegroup2', 0);
  actchild ('tablegroup3', 0);
  actchild ('tablegroup4', 0);
  actchild ('tablegroup5', 0);
  actchild ('tablegroup2[112]', 0);
  flag=2;
}
```

7.4 Individualised Café Review

7.4.1 Method

The purpose of this evaluation was to gather information from teachers to initially assess the design and content features of the individualised café VE prototype. This initial feedback can continue to inform the design process (as discussed in sections 3.4.1 and 3.5) so that future versions of the individualised VEs can be formally assessed in user trials if comments received at this stage were positive. The prototype was reviewed by three teachers at Rosehill School in Nottingham. These teachers were involved in the development of the original level based bus and café VEs, and had used these VEs extensively in their teaching (Wiederhold, 2004). They were not involved in the review of the demo individualisation VEs (section 6.5) and so were not commenting on features that they had personally requested and therefore could give unbiased responses. The review consisted of an expert walkthrough and comparison study where after having the level based café VE features shown to them again (even though they were all familiar with this VE) they were given a demonstration of the features on the individualised café VE. The teachers would take it in turns to try the VE for themselves before completing a short questionnaire.

The purpose of the questionnaire (which can be seen in Appendix H) was to gather feedback concerning particularly three main areas,

1. Usefulness of individualised VEs in general and compared to level based VEs
2. Specific individualised features within the VE and any deemed required.
3. Scenarios - comments on new sequences added

Throughout the questionnaire there were spaces for the reviewers to give additional comments. The questions were as follows;

Usefulness

The following queries were asked for both the level based and individualised versions of the café VE to get an initial reaction and comparison to the usefulness of both. Reviewers were asked to indicate for each element how they rated the program by circling the relevant number on a scale from 0 to 5, where 0 indicates no good and 5, extremely good.

- Suitable for students in my class
- Suitable for students with AS in general.
- Easy to set up
- Easy to use
- Layout of Environment
- Challenge offered to users
- Variety offered to users
- Educational Value

As well as rating these specific elements, the reviewers were asked a series of general questions on the usefulness of the individualised VEs;

- Do you think the Individualised version would be useful?
- Do you think you would be able to use the Individualised version in your workplace?

Features:

The reviewers were asked to indicate how useful they thought specific features of the individualised café VE was by circling the relevant number on a scale from 0 to 5, where 0 indicates not at all useful and 5, very useful. The features of the VE rated were as follows;

- starting position of user
- position of tables
- Empty/Part Filled/Full tables
- Queue Length
- Time waiting in queue
- Scaffolding Level
- Gender of server
- People walking or standing in café

As well as the features already in the program, the reviewers were asked about features that had not been possible to be included at this stage due to time and technical constraints or areas that required further clarification;

- Would you like to be able to save an individual's settings?
- Would you like the program to initiate random settings (e.g. different table positions, availability of food, queue length etc) when it is restarted?
- Is there too much to do in the set up?

Scenarios

The individualised café VE contains new scenarios that were not in the level based café and the reviewers were asked to indicate how useful these scenarios were by rating them from 0 (not at all useful) to 5 (very useful). The new scenarios rated were;

- person pushing in front in queue
- person asking if they can join you at the table
- person receiving phone call
- availability of food
- asking for help

Reviewers were also asked to comment on any other area that they thought would be useful to include in an individualised VE with regards to teaching social skills on top of the features that had been incorporated to some degree into the program, these being;

- physical layout control
- queuing and waiting
- asking for help
- choosing sex of person you talk to
- unexpected events – phone call
- dealing with disappointment – no food
- role user takes – seeing things from other perspective

7.4.2 Procedure

The individualised café VE was demonstrated on a Novatech P3 700MHz, 64Mb RAM, 14" laptop with a joystick and mouse connected. There was no need to initially show the original level based café VE as the teachers at Rosehill had used the program frequently and were familiar with its operation. The interface that controls the individualised parameters was shown to the teachers, with all the elements in it explained by the author, while also ensuring that the teachers understood that the interface and new scenarios were a prototype and not complete, especially from a usability point of view. The author then demonstrated how features the teachers were already used to in the level based café as well as the physical layout of the café could be adapted before demonstrating the new scenarios, explaining each element as the task progressed. After the demonstrations, the reviewers were asked to fill in the questionnaire, with the author on hand to help with any queries. The teachers filled in the questionnaire independently, though were free to discuss features amongst themselves or with the evaluator. Comments given by the teachers during this process were noted by the author to ensure that they were included in the comment sections of the questionnaire by the teachers.

7.5 Review Results

7.5.1 Comparison

	Level Based			Individualised		
Reviewer	A	B	C	A	B	C
Suitable for students in my class	4	4	4	5	5	5
Suitable for students with AS in general	4	3	4	4	4	5
Easy to set up	2	3	4	4	3	3
Easy to use	3	4	4	4	4	4
Layout of Environment	3	3	3	4	4	4
Challenge offered to users	3	3	3	4	4	4
Variety offered by users	3	3	3	4	4	4
Educational Value	4	4	4	4	4	4

Table 7-2: Review Ratings for Level Based and Individualised Café VE

	Reviewer		
	A	B	C
General Comments	I like the idea of being able to make each students experience of the café an individual experience. It would be good to save the defaults and come back to them at any given time. This would be a real bonus when working with students of different levels of social understanding.	Very good as long as it works without crashing. Having some problems with current VE.	Much better, a lot more potential variety and can be made more relevant to each student.
Do you think the Individualised version would be useful?	YES - very useful with our 167 students who use a café on a regular basis in town and in colleges.	YES -	YES - Very much so, definitely the way forward.
Do you think you would be able to use the Individualised version in your workplace?	YES - we have access to lap top computers on which we could work individually with students or on the large whiteboard for group sessions.	YES - Looks like it could be more useful, but again must work regularly without crashing.	YES - might take a bit of effort to set up, but if this process is kept as simple as possible then I see no reason why it couldn't be a useful tool.

Table 7-3: Reviewer Comments on VE Comparison

7.5.2 Features

	A	B	C
Starting point of user	4	4	4
Position of tables	3	3	4
Empty/Part Filled/Full tables	4	4	4
Queue Length	4	4	4
Time waiting in queue	4	5	4
Scaffolding Level	4	4	4
Gender of server	3	4	3
People walking or standing in cafe	4	4	3

Table 7-4: Ratings for Individualised Features

	Reviewer		
	A	**B**	**C**
General Comments	All very good features which can be the basis for discussions. The scaffolding level is good in that it can be used to build up a students confidence. Covers issues of gender and personal space etc.		While gender issues can be important, there is not that much interaction with person serving food.
Would you like to be able to save an individual's settings?	YES - This would be an excellent feature. Time saving for the staff.	YES - As long as it was easy to do and retrieve then this would be very useful.	YES - Definitely, would save time and allow teacher to see how student is progressing.
Would you like the program to initiate random settings (e.g. different table positions, availability of food, queue length etc) when it is restarted?	UNSURE – Wouldn't matter if you'd saved settings for individuals ??	YES – though I imagine if loading a previous users settings then they would overwrite them.	UNSURE – I guess there is already some initial settings and teacher could easily make some changes. Would need to see it.
Is there too much to do in the set up?	NO – Not too difficult, but I'm sure it could be made even simpler! Anything that makes it simple and quick would be appreciated!!	UNSURE – Seems like quite a lot initially, but looks like it can be done relatively easily and loading a students previous settings would save time.	UNSURE – Not too much when considering 1 student, but there could be a lot to do for a whole class.

Table 7-5: Comments on Individualised Features

7.5.3 Scenarios

	Reviewer					
Scenario	**A**		**B**		**C**	
Person pushing in front of queue	4	This is something that does happen in our real life cafes, so being able to discuss this beforehand would be excellent.	4	An important issue, so interesting to allow student a different point of view on this situation.	4	Good to see same situation from others perspective.
Person asking if they can join you at the table	4	Yes, this is useful, especially if it is a student who is out on their own talking about appropriate social interactions etc.	4	Would it be possible to be sitting with a friend or have someone you know approach you? Not many people would approach our students quite frankly if they were in a real café. They have been know to clear out places.	4	
Person receiving phone call	3	Yes, this might be an unexpected event that upsets the student, but this is becoming more the norm in colleges etc., and hasn't been a problem for us (so far!!)	4	I was even taken aback when phone rang so it could prove quite a distraction to the task, reflecting challenges in real café.	3	Unexpected noises are good, just not sure about phone call, quite common these days.
Availability of food	4	This one is good as it could cause major problems when their favourite isn't on the menu.	5	A very good feature to have for our students.	5	Fantastic option – something we have to deal with all the time. Good to learn about disappointment and not always getting what you want.
Asking for help	4	Yes, tricky situations need to be discussed so this feature of asking for help is a good feature.	4	Yes good for tricky situations, though should have more question options like when sitting down.	4	Good to learn to ask an employee for help, though scenario needs improving. Would be good to have more questions and different responses. Perhaps have ability to type in the questions and responses ourselves.

Table 7-6: Ratings and Comments on Individualised Scenarios

	Reviewer		
	A	B	C
Is there any other area, which you think would be useful to include with regards to teaching social skills?	To incorporate some negative attitudes and response which might happen with peers. Young children – fire alarms etc. unexpected events.	More choice of person interacting with race, build etc. Young/old people in VE – there can be a big difference in reaction by students.	Having different people in café to user, e.g. race, size, age. Actually paying for food, saying please and thank you. Going in with a friend/s as opposed to being on own – or meeting a friend.

Table 7-7: Possible Individualised Scenarios

7.6 Discussion of Results

7.6.1 Comparison between level based and individualised café VE

While all the reviewers thought the level based café was suitable for students with AS, both in their class and in general, they indicated that the individualised VE was even more suitable. They did not indicate that the individualised café offered more educational value, but this may have been a reluctance to say that it was perfect as only the maximum rating of 5 was available for the reviewers if they were going to give an improved rating on this issue. All the reviewers thought the new individualised café offered more variety and a challenge to the users, though again did not give the maximum rating which is not surprising as the program was just a prototype and did not offer anywhere near the potential features that it could have in a fully developed program. So it would appear that all the reviewers felt that individualised VEs were the way forward and could be a more relevant teaching aid to students of different levels of social understanding, but that understandably, more work is required developing these programs. There was some uncertainty expressed about how easy the program would be to set up, though the main concern was about making sure the programs ran without crashing. A feature that might ease the setup procedure is discussed in the next section.

7.6.2 Individualised Features

The reviewers thought all the individualised features were of some use, though being able to choose the position of the tables and the gender of the server received the lowest ratings. One reviewer felt the interaction with the server to be too short to really be affected by what gender they were, while the random positioning of the tables in the level based café was probably seen to be just as useful as actually choosing where they went. The reviewers though were mostly unsure about having random settings and this was partly due to the fact that they wanted to be able to save a user's settings each time the progr am was used and would therefore start where the user left off previously. All the reviewers felt that saving a user's settings would be a very useful feature as long as it was easy to set up and would allow time to be saved in the long run as well as see how a student was progressing. This is especially true when considering the use by a whole class as it might be too disruptive to set up for each individual even though on a one to one basis the reviewers felt that there was not too much to do and was not too difficult.

7.6.3 Scenarios

Being able to see a situation from a different perspective was something the reviewers thought was a good addition with regard to having someone push in front of the user in the queue or asking them if they may be joined at the table, even though one reviewer pointed out that it was unlikely that people the students did not know would approach them in a real café, tending to stay well clear. One reviewer thought it would be good if you could be sitting with a friend, incorporating them into the overall scenario, thereby requiring the user to find a place with at least two seats. Alternatively the user could find a seat and is then approached by someone they know who will ask if they can sit with them. Reviewers thought it would be good to have a wide range of questions and responses for when people asked to join the student at their table and thought this would also be useful when the student asks an employee for help. This scenario was seen as being good for 'tricky situations' which is taught to the students though it needed improving and one reviewer wanted the ability to type in their own questions and responses.

The phone call scenario was seen as not being too much of a problem in general as this type of incident happens quite regularly when the students are out at a real café and they are getting more used to it, though the reviewers thought it showed how an unexpected noise could unsettle the user and perhaps forget what their goal was.

Having something less common such as a fire alarm was suggested as being a good addition to the program.

The availability of food on the menu in the café was seen as an excellent feature as dealing with disappointment was something that had to be dealt with regularly, especially with regards to meals. This scenario is not too complex in the prototype with only a small amount of interaction and feedback from the program as it was expected that teachers would want to discuss this situation in detail with the students. This scenario could probably have more detail added to it to aid the teacher in an important teaching issue for people with AS. Other disappointing events could also be added to the program.

Additional features that the reviewers thought would be useful were having more choice in choosing the race, build and age of people in the café as student may have problem in dealing with people different from themselves especially in younger people who might have led more sheltered lives. One reviewer thought that there should be more negative attitudes and responses from people in the café, which might happen in real life if students were interacting with peers. Having a sequence where the user actually pays for their food (as opposed to just clicking an icon which automatically gives correct change for meal) would be a useful addition with the ability to say please and thank you.

7.7 Summary

This chapter has looked at the development of a prototype café VE that can be individualised to meet different user's needs. This prototype was an updated version of the original level based café with all the tasks available in that VE present in the new. The different parameters that can be customised in the new environment through a special interface have been discussed in reference to feature requirements made in the previous chapter. New scenarios such as unexpected events and seeing things from a different perspective have been added to the individualised café VE and are also discussed. The individualised café VE was then reviewed by experts, commenting on the customisable features, new scenarios, anything that could be added and whether this new approach was more suited to students with AS.

Chapter 8. Discussion

8.1 Introduction

The overall aim of this research was to examine the requirements for the optimum design and development of a learning VE teaching social skills to people with ASDs. To achieve this, the author addressed four research questions;

1. What is the role of a VE developer in a multi-disciplinary design process?
2. How can VEs be made usable to support learning for people with ASDs?
3. How can VEs be scaffolded to support learning in the classroom?
4. How can learning VEs be programmed so that they are robust and scalable?

A user centred design approach was used to define the content, interface and structure of such VEs. Observation studies and expert reviews were used to inform scaffolding requirements to aid learning in the classroom. This was done in the setting of a project where initially a product was to be delivered at the end of a fixed period. A flexible, iterative approach saw the VEs evolve both in terms of content and in structure, with the author discovering first hand the role of the programmer in a multi-disciplinary project team and how best to program learning VEs for users with AS depending on content and resources.

This chapter begins by discussing the development of the learning VEs, developed as part of the AS project and discussed in Chapters 4 and 5, and how they were designed as part of an iterative process and the role of the programmer (the author) as part of a larger project team. The content of these learning VEs, how the user interfaces with this content and recommendations for future VEs of this type are discussed. Following this, the principle objective of scaffolding a VE to aid learning and the practical considerations of using learning VEs for social skills training within the classroom are discussed. Scaffolding takes place within the 3D environment of the VE as well as in the interface to the VE and issues relating to the VEs developed in the AS project are considered with regard to whether they are relevant to learning VEs in general. Similarly the practical considerations of the technology and how it is implemented in practice with the help of a teacher discussed in this chapter will have relevance to learning VEs used in any classroom setting.

Issues regarding individualisation of the VEs for people with AS are then discussed by looking at guidelines from literature as well as feedback from reviews of prototype individualised VEs (see Chapters 6 and 7) developed by the author after the end of the AS project. Finally the program structure that underlies everything discussed in this chapter is reviewed. The different ways of structuring learning scenarios are discussed as are differences in code structure between the level based and individualised programs developed to determine the effectiveness of them in their given applications.

Many of the areas discussed in this chapter overlap each other, e.g. many points discussed in the content and interface section are discussed again in scaffolding. Figure 8-1 gives an indication as to the relationship between the different sections of this chapter. As mentioned, usability issues between a VEs content and interface are linked to the scaffolding of learning. This in turn is linked to individualisation with these sections underpinned by practical considerations and program structure. All these areas mentioned are encompassed in the iterative design process. The order in which these areas are discussed in this chapter is intended to closely match the order in which they appear in the thesis and answer the research questions. The four research questions are addressed by the following sections;

- Q1- section 8.2
- Q2- section 8.3, and 8.4
- Q3-sections 8.4, 8.5 and 8.6
- Q4-section 8.7

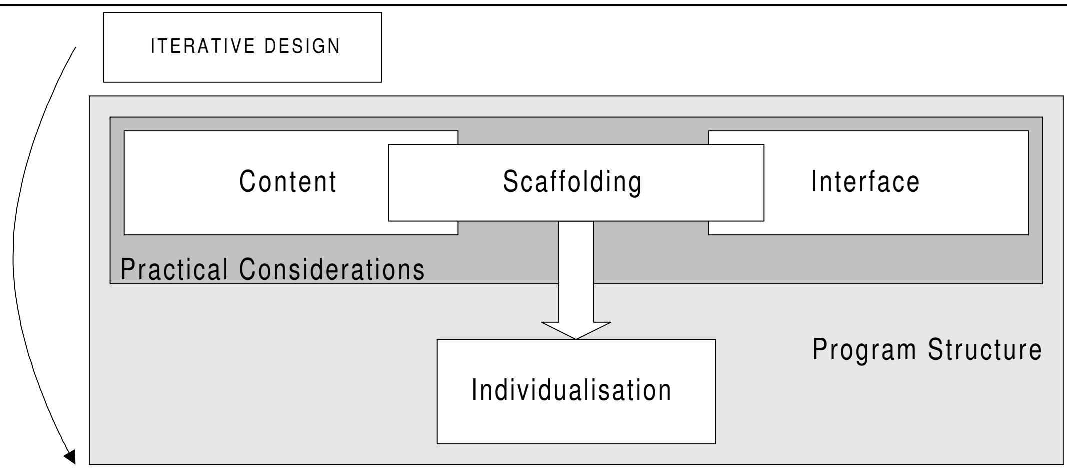


Figure 8-1: Relationship between chapter sections.

8.2 Iterative Design and Role of Programmer

The research in this thesis was initially conducted within the context of the AS project. In this case the VE developer (programmer) is part of a larger overall multi disciplinary, design and development team consisting in this case of domain experts, users, psychologists and interface designers/human factors experts (see sections 3.7.1 and 3.8). Involvement of professional and user representatives in the design and review process is essential to ensure that the final VE design is acceptable to students and teachers alike, can be easily used by them and provides support for the training requirements of the students (Rutten et al, 2003). Even if it is not possible or appropriate for the end user to actively come up with suggestions about learning objectives, their involvement can be more than just testing a VE with facilitated discussion groups exploring what is good or bad about development prototypes. The whole design/development/testing process is iterative with the outcomes of each stage feeding back into the loop for the next. In the case of the AS project, from a programmer's point of view, their place in this process can be shown in Figure 8-2.

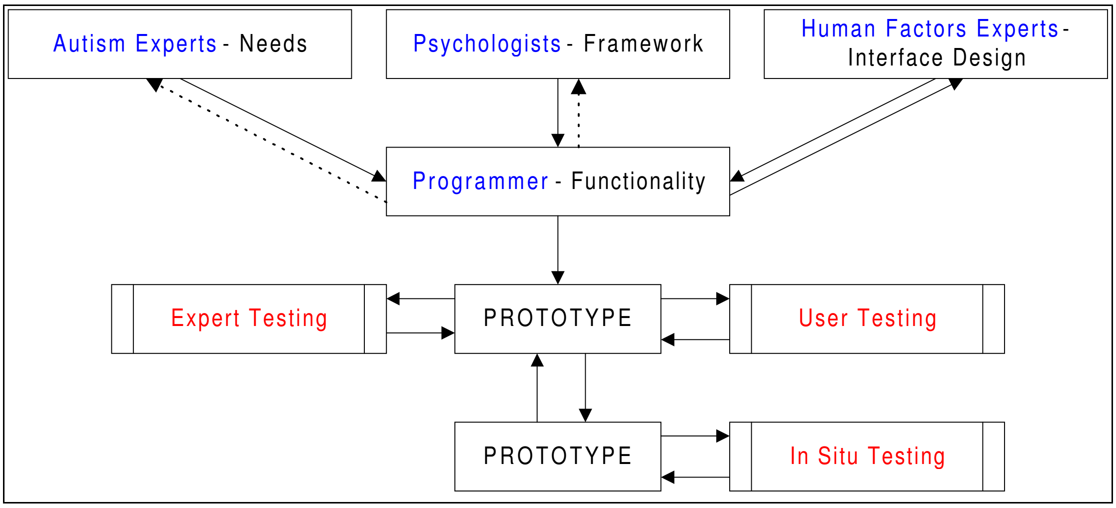


Figure 8-2: Iterative Design Process

The programmer designs the functionality of a prototype VE based upon the needs, framework and scenario design, input by other members of the team. Feedback from the programmer to the other members then in turn moulds their ideas to match the technical capabilities of the VR system or forces the programmer to look for alternative solutions. The programmer works particularly closely with the Human

Factors expert as the interface design is more likely to be altered due to technical considerations. This cycle continuously feeds in the prototype VE which is tested by experts and users. Results of these evaluations effects the content, interface and scaffolding of the VE prototype along with providing information on bugs in the program that require fixing. These cycles continue until the VE has enough functionality, usability and robustness for it to be fully tested in situ. This allows the VE to be further refined, especially the usability and scaffolding of the VE with extra functionality added for both teacher and user. In general, many of these different specialists may not be part of a development project in which case the programmer may have to design the interface themselves through research and experience. There should always be a domain expert on hand as a development project would usually begin with a need for an application and if not, a researcher (perhaps the programmer) would have to explore the needs of the users themselves and adopt a framework already produced for a similar application. Testing could be seriously affected if specialists are not on hand to facilitate evaluation sessions, especially if the users have special needs. As a result, the application may not fully meet the needs of the user.

It is important for the programmer to see first hand how the VEs are used in practice as only then can they fully understand any feedback given by users and evaluation experts alike. Indeed a programmer with human factors experience, understanding of users needs and knowledge of the domain (as the author had in this case) can be a pivotal member of the development team in producing a successful VE. A programmer researching the domain area will obviously be looking at the literature from their point of view, looking for information specifically relevant to the programming of the VEs, keeping in mind limited timescales for completing the project. Combined with the research carried out by other members in the team, each with their own experience and viewpoints can form a think tank to generate useful ideas. These ideas will not be completely distinct from each other, with autism experts suggesting possible technical solutions as well as human factors experts raising issues that affect people with autism. Figure 8-3 shows how each member of the AS project team brings ideas together and can be cross checked against all the experts in the team, thereby meaning each member does not need to research every single detail involved in the project personally.

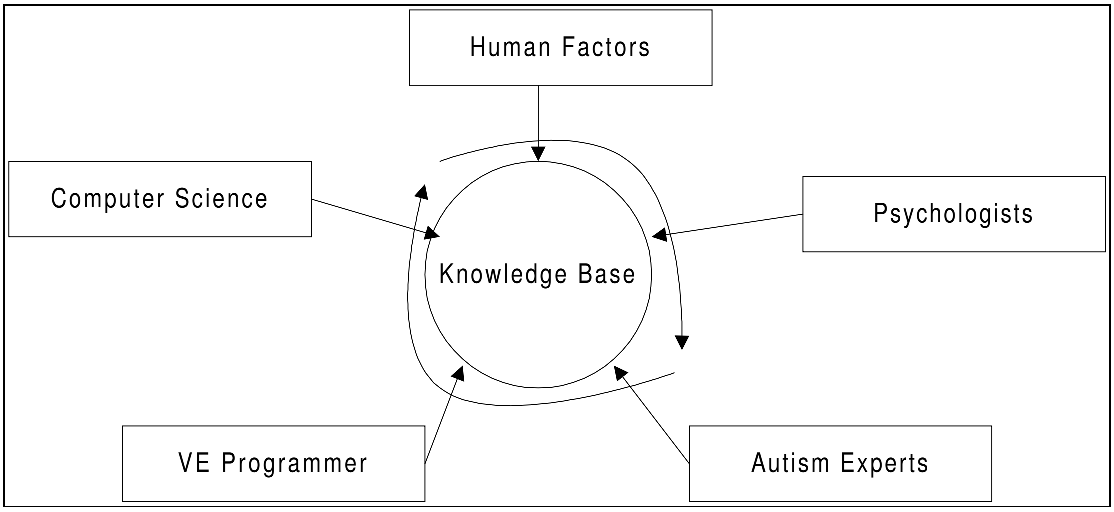


Figure 8-3: Collaborative Design

Figure 8-4 shows how the development of the VEs discussed in this thesis took shape from the initial identification of requirements and design, through the building and testing of the café and bus VEs and then finally onto the individualised VEs. It can be seen that there were more stages to the development of the café and bus VEs as this took place as part of the AS project with a large multi-disciplinary team and so could focus on more design and evaluation processes. The 3D coloured blocks show the VEs at different stages, listing the main elements of the VE (interface, layout etc) that were researched/developed at that point. The blocks are colour coded to show whether they are a café (blue), bus (magenta) or individualised (green) VE.

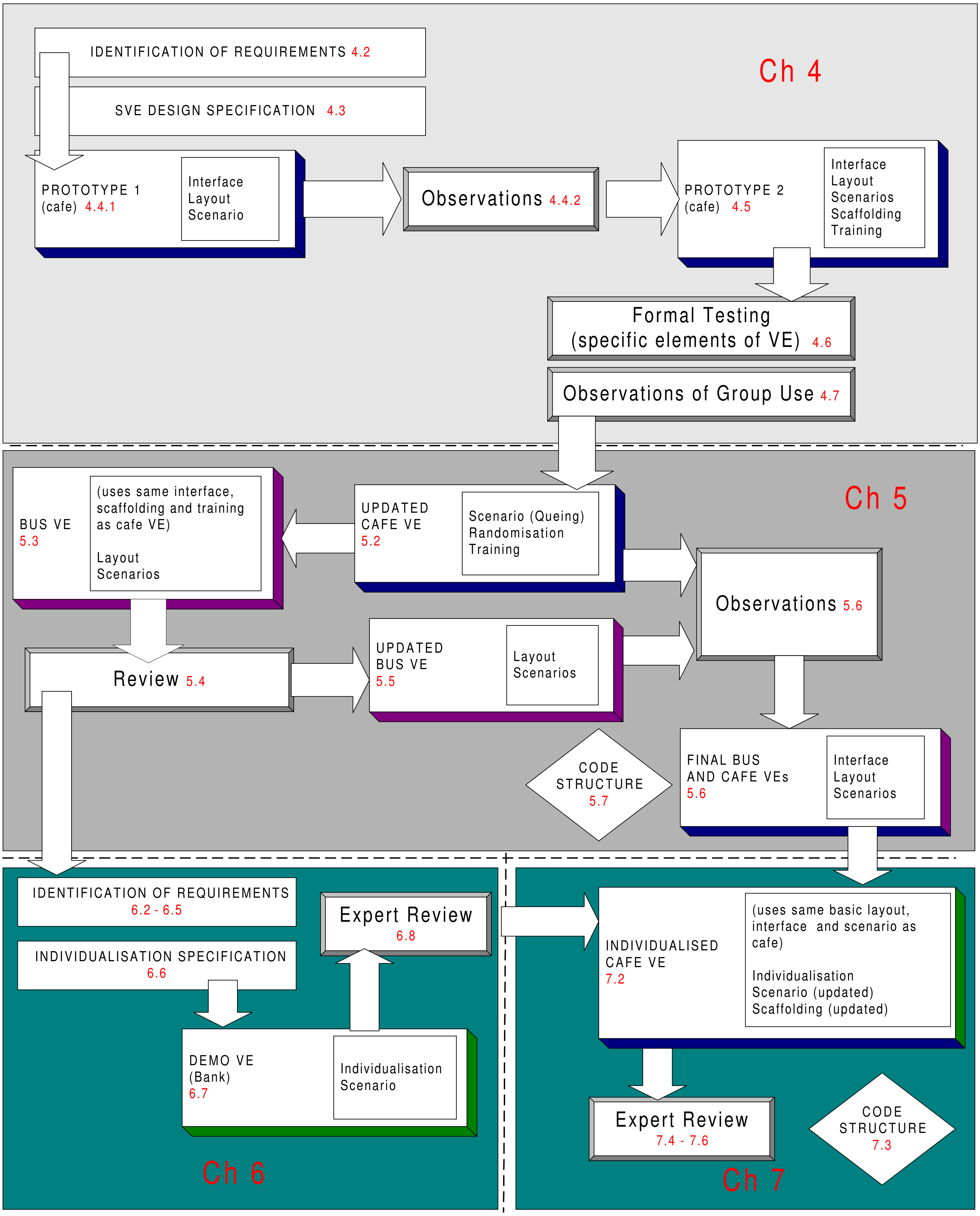


Figure 8-4: Thesis Map of VE Development

From the diagram, it can be seen that the individualised café VE was built upon elements designed and tested earlier and so if setting out to develop an individualised VE from the start, the overall design process would not differ greatly, with a number of iterative stages of development required to ensure the production of useful, usable content and interface elements for the user population. A difference would be that the learning scenarios would not be level based, but modular and tested separately or in groups of modules. Figure 8-5 illustrates the order of element production in a VE and how the identification of requirements and design specification determine their initial aspects while testing further refines them.

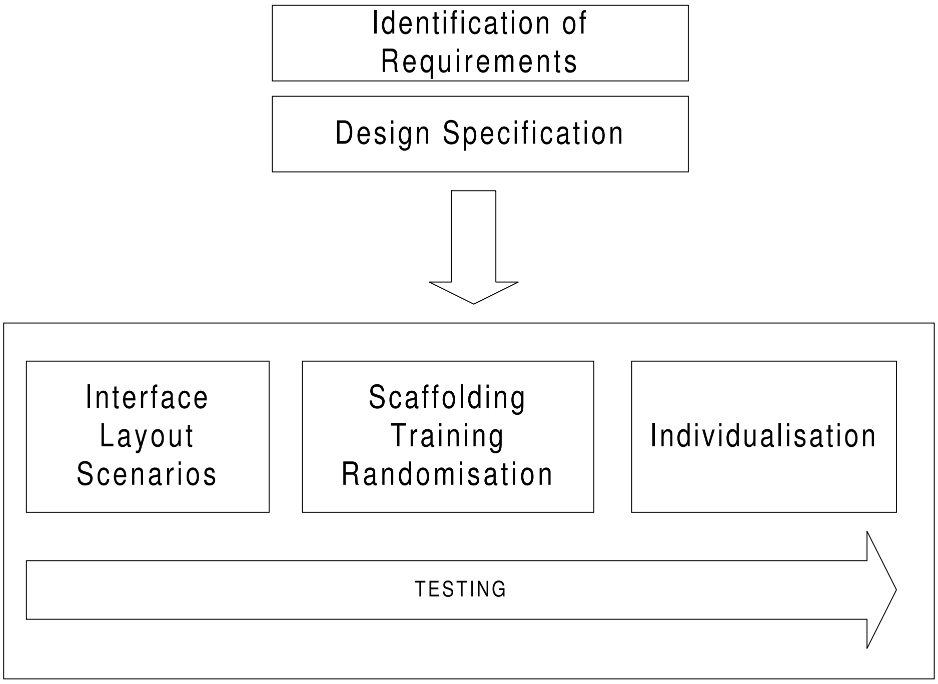


Figure 8-5: Process of VE Element Development

8.3 Usable Content and Interface

8.3.1 Content

Once the learning scenario and context have been decided upon, the developer has to build the 'physical' layout of the VE, i.e. the 3D world in which the user will move around and interact with. Initial models should concentrate on getting enough objects in the VE so that basic elements of the key learning task can be programmed into the prototype and tested (see sections 3.8.3 and 4.4.1). This allows for an initial appraisal of the technical requirements of the program, getting particular programming sequences to work being the priority at this stage, rather than on the usability. Ideally, the layout of an environment would be something very familiar to the user, e.g. the street outside their house with the same bus that they would get, and in an individualised environment (see sections 3.6.1 and 3.6.2), this would be the objective. However even in an individualised VE, getting the exact layout familiar to everyone is probably not always practical and obviously not possible in a fixed layout. Therefore a generalised layout has to be thought of, combining features common in many places of the type that are to be featured in the learning VE. It could also be argued that a layout not familiar to users may help encourage generalisation of the taught principles. To further help in generalisation a mixture of objects and characters can be used, e.g. the people in the VE are as much as possible a varied mix of genders, ethnicity and looks to give a more realistic feel to the program. Different table and chair layouts were used in the cafe to generalise and show that there could be many different styles of furniture in places the user might visit.

If possible, objects in a VE, especially those in a floor area which the user moves around, should be spaciously separated to allow ease of navigation between them or with invisible barriers placed in appropriate places to prevent the user from getting stuck or from accidentally leaving the environment (see sections 4.5.2 and 5.2.2). This is because some users will not be as proficient as others at controlling their movements in the VE and should not be penalised and frustrated in their efforts to learn. Of course if the objective is to create a realistic busy place then having people or objects as obstacles will be necessary in which case the navigational device or program should be set up in such a way that reduces as much as possible, the ability to get stuck, through sensitivity settings of joysticks, automatic movements (when movement not actually part of learning objective) or some creative code that can guide a user around an object (a sort of digital bumper).

Even if individualising a VE, randomness of appearance can be very helpful for people with AS, especially in places that affect learning outcome, such as the position of an empty table in the cafe. This is so that students have to think about what they are doing on each occasion rather than just learning a sequence of interactions which they continually repeat. For instance, the position of avatars in the queues are varied so that the user does not just learn to 'stand behind the person with the green jumper'. Randomness could also just be about giving a different feel to the scenario, e.g. changing the décor of the VE to give the student a feeling of variety and keep their interest. There still has to be some degree of control on the randomness however as a teacher may wish to use the same set up more than once with a user, so a button or icon could be used to switch the random features off or in the case of the bus and café VEs the layout remains the same until they are reset.

When building a VE for people with autism, the developer has to use colour carefully so as not to overload the users senses, though this is something that could be scaffolded with a subtle use of colour to begin with and then increasing colours to match those in a real situation as the user progresses in their learning (see sections 4.2.1and 4.5.2). The amount of people and their movements can also be scaffolded, so the developer has to create all these objects and décor and program in the ability to switch these elements on or off or to appear automatically depending on the scenario or apparent level of difficulty.

Due to the number of virtual people likely to be in a social VE and the fact that each person is made up of a large number of facets, then clipping of objects has to take place for the environment to run as smoothly as possible (see section 5.3.1). This means that objects that cannot be seen by the user, e.g. once on the bus a user cannot see the outside of the bus or certain buildings in the city, wheels and outside panels of the bus as well as some buildings, are made invisible to help the processor deal with the objects that are required to be rendered. This prevents rendering problems such as people disappearing momentarily in front of the users eyes, destroying the illusion of being there. This can depend a lot on the PC being used and developers should be aware of the likely equipment their target audience will be using.

Table 8-1 summarises the above guidelines for content development, indicating whether a recommendation is for learning VEs in general or specifically for people with AS.

Content Issue	Guideline	Application
General Layout	Have generalised layout for context.	General
	Have variety of objects and people.	General
Movement	Space objects out to allow ease of movement between them.	AS
	Adjust sensitivity of input device.	General
	Automatic movements and orientations when required.	General
Randomness	Randomise position and look of objects relevant to learning objective.	AS
	Randomise look of objects for variety and interest.	AS/General
	Allow teacher to control whether randomisation occurs.	AS
Stimuli	Have careful use of colour, amount of virtual characters and their movement	AS
Number of Objects	Use clipping – do not render objects if not in view or render a lower resolution version of an object if viewed from a distance.	General

Table 8-1: VE Content Development Guidelines

8.3.2 Interface

The interface to a VE is how a user interacts with the environment and can include a 2D layout of buttons or icons as well as pop up menu options. These methods of interaction are employed when there is no easy metaphor that can be used within the 3D world (see sections 3.2.6 and 4.5.5). The interface can be used to not just control an environment, but offer feedback in the form of alerts or informative messages to the user or teacher. Graphics used as a metaphor to represent meaning for an icon should be familiar to a user or easily learnt and remembered. The café and bus VEs use a £ icon to represent payment, a speech bubble when the user wants to ask a question and a thought bubble to find out 'what another person is thinking' button so as to enable the user to see other peoples perspectives on any inappropriate behaviour they had exhibited which teachers find difficult to convey. The interface to both scenarios is uniform which is important as users can quickly learn a handful of icons as well as interaction metaphors allowing them to experience a vast range of different scenarios in a relatively short period (see section 5.3). The '?' and 'ear' icons used in early prototypes were seen to be mostly redundant and were removed to prevent the user from having too many options, which can be disruptive and confusing (see section 5.6). In fact the user should only be presented with an interaction icon or metaphor when it is appropriate. This is termed a dynamic interface, which clearly shows the user what is possible at any given moment and allows them to easily locate where to press instead of searching through a wide array of buttons (see section 2.9).

It also prevents the user from accidentally selecting an option that does not work and gives a clear visual indication to the developer about which options are live, thereby hopefully reducing the time to test and debug. Disabling the level selection on the interface was also useful as it was observed that many students, whilst in the middle of a level would accidentally or intentionally click on another level and therefore not complete the current level they were on. As the teacher may want to change the level at any time if they feel a student is having difficulty it was decided to remove the interactivity from the interface on the screen and have the levels selected by pressing the corresponding number on the keyboard. Developers of VEs for people with special needs have to be aware that users will try and move everywhere and click on everything at every moment and program the environments accordingly.

Teachers will want to discuss and reflect with their students what has happened in the VE and will require the full attention of the user and for them to stop at their current place in the program (see section 5.6.1). Again users are likely to want to keep going or click on things and so a pause button should be incorporated that can only be controlled by the teacher, allowing them to 'freeze' the VE at any time. There will be certain parts of the program in which the teacher will always want to speak to the student and so the program can automatically stop at these points. When the program is paused, it should be obvious what to do to get back to 'active mode', so the pause dialogue box which appears should include information on how to carry on, e.g. 'press Enter to continue'.

As with the layout of objects sometimes it is beneficial to have randomness in the interface. This is the case with dialogue boxes, which the user chooses a question for them to ask someone in the VE. A wide variety of questions with positions of appropriate and inappropriate questions altered will require the user to think carefully about their interactions rather than continuously repeating a selection.

Table 8-2 summarises the above guidelines for interface development, indicating whether a recommendation is for learning VEs in general or specifically for people with AS.

Interface Issue	Guideline	Application
Interface Content	Use metaphors that are familiar or easily remembered	General
	Have option to find out other persons perspective in scenario	AS
	Interface should be uniform across VEs	General
	Use dynamic interface	AS/General
	Disable level selection by user.	AS
Interaction	Disable object interaction when not required.	AS
Teacher Control	Allow teachers to pause VE	AS/General
	Inform teachers how to proceed with scenarios.	General
Randomness	Randomise interface elements such as questions in dialogue box.	AS/General

Table 8-2: VE Interface Development Guidelines

8.4 Scaffolding

The construction of scaffolding within the VEs in the AS Interactive project has been challenging as, by their very nature, VEs are intended to offer the user freedom to choose how to navigate through and interact with the VE. Whilst it is important to allow users some freedom, particularly in making choices about social interactions, there is a danger that unstructured VEs could result in users missing out some important learning sequences (Kerr, 2002). Scaffolding a VE to promote learning has to include structure both within and outwith the system, though both are interconnected. Structure outwith the system will include lesson strategies, student forms (to fill out as task is undertaken), picture cards and real site visits. The structure within the system has to take into account varying levels of ability and be able to guide the user down appropriate learning paths. The level of scaffolding is seen as being at its optimum in the beginner levels (or equivalent in an individualised VE) of an SVE, with it slowly being dismantled as ability and learning scenario complexity increases. (Section 2.7 looks at literature regarding scaffolding).

Figure 8-6 shows the areas of scaffolding within the VE (the 3D environment) and the Interface (term to describe both the permanent 2D interface to the VE as well as user inputs such as dialogue boxes) discussed in this section and how they relate to each other. Some issues affect both the VE and Interface while ‘cues’ are an issue in themselves while also being an important factor in other scaffolding issues.

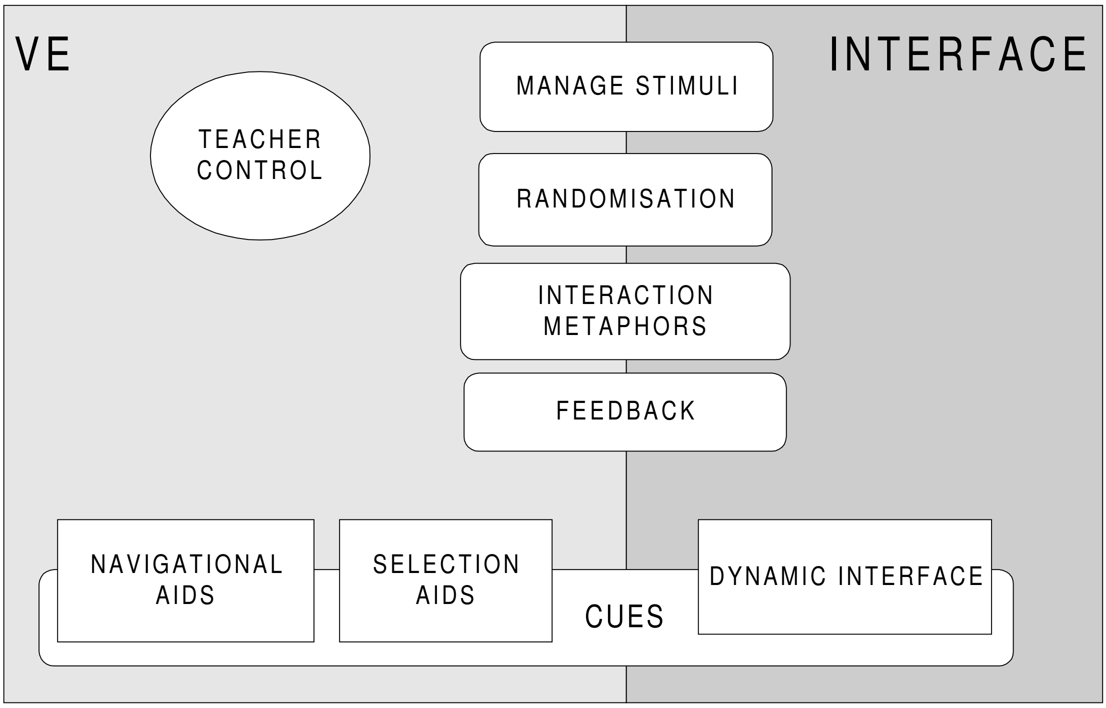


Figure 8-6: Scaffolding Issues in relation to VE and Interface

Table 8-1 below shows the scaffolding guidelines that will be discussed in the following sections and whether they are specifically aimed at people with AS or can be used generally in learning VEs.

Scaffolding	Guideline	Application
Cues	Have red flashing border to indicate what to select or where to go	General
	Limit amount of cues, show in highly scaffolded levels/scenarios.	AS
Navigational Aids	Space objects out to allow ease of movement between them.	AS
	Use invisible barriers to prevent users getting stuck behind objects	AS/General
	Automatic movements and orientations when required.	AS/General
	Detect proximity of user to required position to determine when close enough.	AS/General
Selection Aids	Make virtual objects bigger than in real life	AS
	Have larger selection area around objects.	AS/General
	Use icons on interface	AS/General
Randomisation	Randomly position objects and dialogue to prevent rote learning.	AS
Dynamic Interface	Show only selectable icons when they can be used.	AS/General
Interaction Metaphors	Use metaphors that are intuitive to user	General
	Build training of metaphors into VE	AS/General
Feedback	Give continuous feedback both visually and audibly.	AS/General
	Explain current options to user	General
	Give positive feedback when something done successfully.	AS/General
Manage Stimuli	Slowly expose user to more stimuli until real world conditions approximately met.	AS
Teacher Control	Provide ability for teacher to pause VE.	AS
	Automatically pause important events.	AS

Table 8-3: Scaffolding Guidelines

8.4.1 Cues

Cues are visual aids which can help the user in selection and direction. These usually consist of red flashing borders that are either around the object within the VE to select e.g. ticket machine on bus, or on the interface icons, e.g. pay for your meal icon (see sections 2.7, 3.4.2 and 4.2.3.2). Cues can also be used to show the user where they should go, e.g. food counter in café, where these could disappear as the user reaches appropriate point in environment. While there should not be too many cues of this type as they may provide too much stimuli for people with AS, they can help teach interaction metaphors in the easier scenarios where there is not much else either in terms of stimuli or thought required for the task and so therefore manageable by the student.

8.4.2 Navigational Aids

While a significant benefit of VEs is the ability for a user to explore 3D space in their own time, the user could be distracted from the task in hand or struggle due to either a lack of control of the input device or due to a cluttered environment (see sections 2.4.2.2 and 2.6.7, though note that users with AS in tests were found able to use a joystick, see section 4.2.3.3). If possible there should be plenty of room to navigate around objects, e.g. tables in the café are separated spaciously. If this is not possible, e.g. tight confines of bus cannot be altered, invisible barriers can be used to created channels that the user can move down, preventing them from getting stuck behind objects. If at certain times, navigation is not an important learning objective, e.g. keeping up behind last person in queue (learning task involves user *waiting* in queue and retain control of movement until set time has passed), then auto movements can be used where control is briefly taken away from the user and are moved by the program to the next relevant position for the learning scenario to continue. Auto viewpoints can also be used if at certain points it is beneficial for the user to be facing in a specific direction and angle (see sections 2.6.6, 2.6.7, 2.9 and 5.8). If navigation is important to the learning task then the program can detect the proximity of a user so that if they are in approximately rather than exactly in the right place then the scenario can advance.

8.4.3 Selection Aids

As some users may have poorer motor control than others then not only will they find it more difficult to use a joystick but also more difficult to use a mouse. While different navigation and selection devices are available and some may be more appropriate to certain users than others, the VE should make it as easy as possible for objects to be selected (see section 2.7). This can be achieved by either making the object in question bigger than usual or make a larger area available for selection e.g. user can select any chair or table in a group to sit down (see section 5.6.3). If either of these options are not possible or appropriate then buttons on the interface can be used to instigate a selection, e.g. food on café menu (5.2.1) or paying for bus ticket (5.3.2 and 5.6.2).

8.4.4 Randomisation

The random positioning or look of objects relevant to the learning task e.g. empty table in café, appropriate questions or people in queue is important so that users with autism do not learn by rote, but have to think carefully about their choices and actions (see section 5.2.2). A random look to the environment can also help with generalising the scene so that the VE does not look the same all the time. While randomisation is itself not scaffolding in that it does not help a user complete a task, the amount of randomisation used can be altered to enable a user to learn. It may be necessary in some situations for the layout and feel of the VE to remain constant while a user gets used to other features such as the interface. As a user becomes more proficient in all aspects of the VE then more randomisation can be used to offer a greater challenge.

8.4.5 Dynamic Interface

A dynamic interface (see sections 2.6.7 and 2.9) prevents the user from accidentally selecting the wrong icon while at the same time showing the options available to them at any given moment. From a usability point of view, a dynamic interface would remove icons not even relevant to a particular scenario e.g. removing paying for food icon when communicating with a person at a table. From a scaffolding point of view only the correct icons or buttons could be displayed initially, progressing to a number of choices that are relevant to the task, but not all correct for that given moment. For instance when asking someone in the café a question a more scaffolded level could have only appropriate questions, while a less scaffolded scenario could have many inappropriate questions added to the list to choose from.

8.4.6 Interaction Metaphors

Interaction metaphors (see sections 2.6.6 and 2.8) are symbols or interactions used to represent an action within the VE e.g. clicking on a speech bubble icon to speak or click on a chair to sit down. The learning of metaphors used in the software should be as intuitive as possible, though there will need to be a certain amount of training for these. It has been shown that this training would be better inbuilt into the actual learning scenarios themselves (see sections 4.5.5 and 4.7). The metaphors used should be well known or follow a convention whereby once a user has learnt a couple they can more easily work out ones which they have not used so far. Cues as mentioned in 8.4.1 can be used in easier levels help the user learn metaphors by indicating what to press at a given time. In the research presented in this thesis, users were able to understand and use metaphors (see section 4.2.3.3).

8.4.7 Feedback

There should be continuous feedback given to the user so that they are aware what their current situation is and what options are available to them (see section 2.6.6). Feedback is given audibly in terms of speech and visually in terms of text and cues (section 4.4.1). Visual cues are not just objects such as flashing banners mentioned in 8.4.1, but things like people turning their heads towards the user to acknowledge they are listening to them (section 5.2.2). A highly scaffolded scenario could explain options to a user before they even attempt to do anything and then given further assistance if they carry out the task incorrectly, e.g. in the café the user can be told that they can ask a person at a table to sit beside them or move away to another table, if they then try and click on seat to sit down they could be told that they should ask first. As scaffolding is removed then the user would need to know themselves what options they had and if they carried out a task incorrectly they would be informed and asked to try again, but without indicating what they should do. The program should keep track of actions or responses made previously by the user as this could influence the help given (see section 2.7). For instance in a highly scaffolded scenario the user should experience a positive outcome for correctly carrying out a task (e.g. being told that a seat is available when they ask an appropriate question). If scaffolding is removed then they may be told that someone is sitting on the seat even though they correctly asked an appropriate question, again to reflect possible real world events.

8.4.8 Manage Stimuli

A lot of noise and movement can be disorientating for a person with AS (see sections 2.8 and 5.2.2). Therefore a highly scaffolded scenario could remove non task-critical noises and movement e.g. background noise and people walking around and have these elements slowly added as the user gets accustomed to them as the environment begins to represent more and more real life conditions.

8.4.9 Teacher Control

Not for the user, but for the teacher to pause the VE to allow discussion and reflection on events experienced by the student (sections 5.6.1 and 5.8). If particular events always require discussion (due to VE not being able to adequately explain or demonstrate all eventualities) then the program should automatically pause at these places.

8.5 Practical Considerations

8.5.1 Technical

The first consideration from a technical viewpoint is what hardware will the VE system be running on. This in turn will dictate the possibilities for which software platform can be used to develop the learning VE and the types of interactions which can be made with the interface. The reason hardware is the first consideration is one of cost and availability. In an ideal world the learning VEs would be developed on leading edge software for leading edge hardware by a large team of developers, constructing an education environment as rich in detail as leading console games used in a modern hi tech school with technically savvy teachers. This unfortunately is not the case and the first consideration by anyone in the development team will be – 'who is going to be using the system and where'. 'Who' is going to use the system should remain fairly constant, as it is a specific user group whose needs drive the research and development goals. 'Where' might not always be so constant and this might need to be taken into consideration at the start of the project.

In the research presented in this thesis there was an initial hope that VEs developed could be used at home, possibly over the Internet as well as in school. This did not impact on the end hardware used, which in each case would be a standard desktop PC, but might have implications on the interface to the system depending on the delivery method, especially if content is used online. Superscape could be used as the development platform as there is a plugin, which can be added to a web page to allow online use of the VEs, though it was envisaged that a more likely outcome would be for VEs to be downloaded and installed on individual PCs with the use of Superscape Visualiser which could also be downloaded and installed. The only real benefit of using a VE online is if a collaborative version is used where more than one user could interact in the same environment. Superscape did allow for collaborative environments to be set up, but the author was not experienced in this and with

Superscape no longer supported, it was felt that any attempt at building CVEs should be made by a different development team using software they felt appropriate, copying content and interaction methods as determined by the research in the single user VEs.

Whilst most PCs in schools and homes would now (based on average spec of PCs currently sold) have little problem in running desktop VEs, ideally an investigation into the specs of machines that the target user population have access to is desirable. Developers have to be aware that the PCs they use to program the VEs may be more powerful than users PCs and so should design the environments accordingly. This might result in a trade off between the smooth rendering and updating of the VE and the graphical detail it contains (it might not be possible to load the VE with photo-realistic textures and lighting effects). However, a more likely cause at present for VEs to look unrealistic is the fact that console games which are developed by companies with budgets of several million pounds have now raised peoples expectations which cannot sadly be matched by developers of specialised educational software.

As development of the VEs follows an iterative process with frequent user tests in situ, then the VEs should either be able to be easily installed on a users PC or be taken on a portable device such as a laptop computer, which becomes especially important if technical assistance is not always on hand for some evaluations. The input devices used for interaction with the VEs will also need to be thought about and whether specialist devices need to be bought or tested for their compatibility with the VE platform.

8.5.2 Role of Teacher

In many cases, when using the SVEs, the reasons as to why certain responses were given by the computer or the actions available to a user will have to be taken up by teachers monitoring the progress of the student. The teacher can use the experiences of the students in the environments to facilitate open discussions to further aid the learning (see sections 5.8, 6.2.2 and 6.2.3.3).

With early teacher input and collaboration, and with the support of school and department heads, it was found that using a social skills learning VE in the classroom as part of group discussions, appears to be successful with great potential. Group discussions, guided by the teacher and following appropriate, interactive, experiences can be directed in a meaningful way to the students concerned who are more open and involved when learning with their peers. This is of course, if the teacher feels that they can use the software effectively and the software must allow them do to so. A 'pause' button (see 5.8), which only the teacher can access is used so that scenarios can be halted at any time for discussion of what had just happened to take place. The teacher should also be able to intervene before each user starts by structuring the VE to suit the learning needs of the individual, e.g. in the bus and café environments, the teacher should be able to decide where the virtual people are sitting and even what questions the user might be likely to ask (see Individualisation in section 8.6). Individual adaptation, along with good class preparation by the teacher could pave the way for an enriching learning experience for both teacher and students. The software will not only have to be relevant and fit into the teacher's strategy, but be varied and interesting enough to cover all issues which the teacher wishes to look into and to hold the student's attention and enthusiasm, outcomes found also by Crosier et al (2000) and Hutinger and Rippey (1997).

8.5.3 Facilitating Use

The learning tasks offered by the VEs themselves should fit into the overall teaching strategy in schools at present so that learning can be compounded on at all levels within the classroom, otherwise they will just be another gimmick that passes without delivering a positive impact (see sections 5.8 and 6.3).

As well as a supportive infrastructure within the school, adequate support materials can be provided with the VEs. These support materials can be both electronic and paper based and aimed at the VE learning facilitator which could be a teacher or parent. Support materials were created for the level based bus and café VEs by other members of the AS project team with the help of teachers, though these were not formally reviewed and should form part of any future research into learning VEs for people with AS. Examples of the support materials used in the AS project can be found at www.virart.nott.ac.uk/asi/facilitator.htm.

A possible obstacle to the use of learning VEs is actually getting them set up in the first place and then running them without the system or peripherals being difficult to use. There is no point having a great learning package if it just sits on a shelf unused due to an awkward installation procedure or a lack of robustness. These issues can initially be thought of as technical points for consideration such as those mentioned in 8.5.1, though these directly affect the uptake and usage of the software. Developers need to ensure that a VE and its constituent parts can be loaded onto a system easily without affecting other software or systems running on the PC. There has to be an awareness that people expect to just be able to click on a button or install a CD and let the system get on with it, without the need for personal intervention. A user installing software is also likely not to read instructions to begin with (until things go wrong) and allowances as far as possible should be made. The VE itself should be robust enough to cope with any possible usage, which in the special needs environment usually means that all buttons and movements on input devices will be activated and the user will try and navigate to all parts of a VE and activate all objects all of the time. Therefore events within the VE or interface-procedures should be allowed to be triggered only if appropriate, to prevent starting multiple pieces of code that might conflict with each other and 'crash' the system. This though falls into the usability issue of dynamic interfaces (see 8.4.5), which concentrates on preventing the user from getting confused, disorientated and frustrated within the VE. Input devices, particularly specialist ones may require setting up and configuring separately from the VE and problems could arise from the use of such input devices with the VEs. Users should be made aware as far as possible of issues relating to certain input devices and what they can do to remedy problems and whether it is a fault with their PC rather than with the VE.

Due to cost and technical restraints within the AS Interactive project, it was not possible to provide a fully self installing program, though a setup which relied on minimal input from a user to begin with was achieved with instructions provided in a starter pack. Due to the VEs being run on an external piece of software (Superscape Visualiser), control of input devices was through this program. Therefore the desired input device of a joystick had to be installed and set up separately also. This was particularly relevant to the sensitivity of the joystick which would differ from PC to PC depending on its processing power and therefore could not be set up within the system in advance. Instructions were again provided with the starter pack (and online) as well as a trouble-shooting guide, which would allow the user to resolve the most commonly expected faults. (See www.virart.nott.ac.uk/asi/troubleshoot.htm)

8.6 Individualisation

8.6.1 Literature Guidelines

For VEs to provide a useful learning experience then they should be tailored to the individual either by the student or teacher and contain scaffolding to guide the user and inform the teacher if help is required (see section 6.3 for a summary of all recommendations discussed in this section). In the case of users with AS then teachers (or similar) would normally set the individualised parameters. Scaffolding in an individualised VE is the same as in a level based VE, but rather than the level of difficulty determining the amount of scaffolding, the teacher can specifically set the amount and type of guidance available. Intervention and problem solving can be achieved through discussion between teacher and user or through the software program giving available options automatically to the user.

Desktop VE learning software requires scaffolding and individualisation to be incorporated from the start. Teachers and autism professionals have to be consulted to identify the key features of both the 'physical' 3D model and the interactive features of the VE they deem most appropriate to have control over, to facilitate the learning experience, while collaborating with the designers to determine how best to allow these modifications to be implemented taking into account technical and usability considerations. The scaffolding built into the VEs to guide the user through these learning experiences will have to take into account this individualisation across all levels of difficulty. Indeed, it is the user's ability, which will influence adaptations made and in turn determine the type of scaffolding required and therefore the difficulty level. It is envisaged that teacher/parental control should form a key part of any future application.

Individualised learning software requires open, flexible, interoperable architecture that can deal with change. Therefore learning VEs should be constructed in modules that allow content to be more easily accessed, changed or selected in conjunction with other material. It is advised that audio and video material within programs be kept to a minimum, as these are difficult to maintain change. However in teaching certain subjects and especially social skills to people with special needs, there is a requirement for this media. Another problem with most learning software is the ability to submit answers in natural language or for the system to cope with open questions. In the review of the individualised café VE in this thesis, teachers expressed a desire to be able to input their own questions and responses into the VE. Improvements in technology such as voice synthesis and speech recognition could help in the long term while currently some of these issues could be addressed with a CVE. These allow a combination of natural behaviour and system control to guide the learning, with the teacher taking on the role of assessor of the students social interactions with the software checking the students 'physical' interactions within the environment or choices they make.

There has to be a supportive environment for the learning software, where it fits into the overall learning strategy and is used in conjunction with other teaching methods. The software should be usable with the interface made as intuitive as possible, though it may require some demonstration by the teacher. The actual learning scenarios however, should be attempted by the user at their own pace using trial and error, but using inbuilt scaffolding to guide them and offering options when in difficulty to reduce frustration.

The choice of software platform used in learning software should be determined by evaluating the suitability of their features with respect to users' needs. This will include assessing the software's ability to provide scaffolding and support as well as capacity for teacher individualisation as detailed above.

8.6.2 Guidelines for Individualisation of AS Learning VEs

This research demonstrated that it is possible to construct VEs to support individualised configurations. Teachers who reviewed the prototype VE considered that the features would facilitate teaching students with ASDs. Guidelines for development of individualised learning VEs for students with ASDs are discussed in the following sections.

8.6.2.1 Comparison between level based and individualised café VE

Individualisation of learning VEs was seen by expert reviewers (teachers) to be extremely useful and a much needed requirement for teaching people with autism. Future scenarios would have to be relevant to the user population (in terms of age, gender and ability), though individualised VEs were deemed by experts to be more suitable than level based programs (see section 7.6.1) and they also offer more variety and challenge to users. Individualised VEs should be relatively straightforward to set up, despite the complexity they offer, and run in a stable manner without failing.

8.6.2.2 Task in context

Having different situations in which people with AS can practice the same task in different contexts, helps to show that there could be different approaches taken to completing a task depending on circumstances and could instil an understanding of generalisation (see section 6.5.4.1). Tasks should not just be shown in different contexts, but have a number and variety of challenges as teachers felt the queuing task in the VE could benefit from exploring issues that can be problematic for people with AS.

8.6.2.3 Issues for People with Autism

Subtasks such as queuing and waiting, interactions with opposite sex etc, are general social skills that relate to many situations a person with AS could encounter and are therefore key issues that should be incorporated within a social skills learning VE. Other such general issues are unexpected events such as noises, unusual (to the person with AS) physical features, and emotions. Inappropriate contact, turn taking, being part of a team and lack of understanding of humour as well as dealing with disappointments are also seen to be crucial factors that need to be addressed within future social skills learning VEs (see sections 6.5.4.2 and 7.6).

Unexpected noises (section 7.2.3) can unsettle people with AS and make them forget what their goal was. Such a noise would also have to be relatively uncommon as certain noises such as ringing phones might occur at any time, but are so frequent that people are used to them.

Dealing with disappointment (section 7.6.3) is something that has to be dealt with regularly by people with AS, especially with regards to meals. This is an important issue in general and scenarios dealing with such disappointments should be high in detail to aid the teacher and many more disappointing events should be researched and covered in future learning scenarios.

Choosing the race, build and age of people in a VE is important as students may have problems in dealing with people different from themselves especially in younger people who might have led more sheltered lives. More negative attitudes and responses than those presented in the individualised café VE are required in future developments as such incidents happen regularly in real life when students are interacting with their peers (section 7.6.3).

Seeing things from another persons perspective was also seen by teachers as being a helpful feature that VEs could accommodate, especially taking into account the lack of ability in dealing with generalisation or empathy that many people with autism have.

8.6.2.4 Software Features

Features that can be individualised within the cafe scenario include the layout of the VE with the position of the tables and how full they are being selected along with whether there are people standing or walking around the café (see sections 7.2.1 and 7.2.2). The starting position of the user, which also affects how the scenario will initially look, can be selected along with the gender of the person serving food. Features directly affecting the learning scenarios in the café VE include the time the user has to wait in the queue before it moves along with the amount of scaffolding (help) they receive.

Sometimes the random positioning of certain objects may be just as useful as actually choosing where they go in certain circumstances. If it is not absolutely necessary in the context of the learning scenario to choose exact positions then randomly positioning objects can be quicker, especially in the reduced set up time for the teacher. This though would be less of an issue if the VEs allowed a user’s settings to be saved each time the program was used, ensuring the user would start their next session where they left off previously, both in terms of progression through a learning objective and the settings of all the individualised parameters. Being able to save the setting and parameters of the VE for each user would be extremely helpful (6.5.4.3

and 7.6.2). This would allow each student to start where they left off each time they use the VE and allow an unbroken progression of learning as well as allow a teacher to see how a student was progressing. It would also save time for teachers in the long run, not requiring them to set up scenarios at the beginning of a teaching session, which is especially true when considering the use by a whole class, though there would be a requirement for more preparation work before any students begun using the system.

8.6.2.5 Scenario Features

Being able to see a situation from a different perspective e.g. having someone push in front of the user in the queue or asking them if they may be joined at the table was seen as a useful feature by teachers, even though it is unlikely that people with AS would be approached by people they did not know when in a social setting such as a café (see section 7.6.3). The level based bus and café VEs discussed in this thesis contain a feature that allows the user to find out what another person thinks of their actions while the individualised café puts the user in the other person's situation to experience what they were experiencing. Both features though can be utilised in either type of learning VE as they are scenario based and can be experienced either by direct selection in a customisable VE or due to an appropriate difficulty level being selected.

Teachers felt that social learning scenarios should incorporate the ability for a user to perform a task with a friend, e.g. having the user to find a place in the café with at least two seats. Alternatively the user could find a seat and is then approached by someone they know who will ask if they can sit with them. The friend could just be a likeness of someone the user knows, though the ability of a VE (of a cost suitable to schools) to quickly and accurately render a virtual person that is recognisable to users is unlikely. This is something that requires further investigation as VR technology improves, looking at scenarios where the user carries out a task individually, but has to take into consideration someone other than themselves. Alternatively there could be a collaborative task (in a CVE) where the user and a friend have to help each other to complete the learning objective (see section 7.6.3).

Teachers thought it would be good to have a wider range of questions and responses for when users interact with people in the VE than was currently provided in either the level based AS VEs or the individualised café prototype. Teachers also wanted the ability to type in their own questions and responses for their students (see section 7.6.3), though this would probably require speech synthesis that sounded very natural, especially to a user with AS, if they were to feel immersed in VE and learning task.

8.7 Program Structure

8.7.1 Learning Structure

The structure that learning scenarios took in earlier VEs was a simple linear model where sequences had to be completed in a specific order (see sections 2.4.2.1 and 2.9). Even slightly more complex learning VEs will follow a linear model to a degree. This can be shown in the model in Figure 8-7. Although different paths can be taken, the movement of flow can still effectively only go along specific lines with one sequence being completed before the next adjacent sequence is attempted. These are parallel sequences where a choice by the user at a certain point triggers an alternative path. For instance a user could get on a bus and decide to pay by either cash or use a bus pass. The choice would influence what happens next in the scenario as if they paid by cash they would have to insert the correct change and if they used a bus pass they would just have to show it to the driver each requiring different interactions within the VE. The person with the bus pass could then just sit down while the user paying with cash would have to collect their ticket before finding a seat.

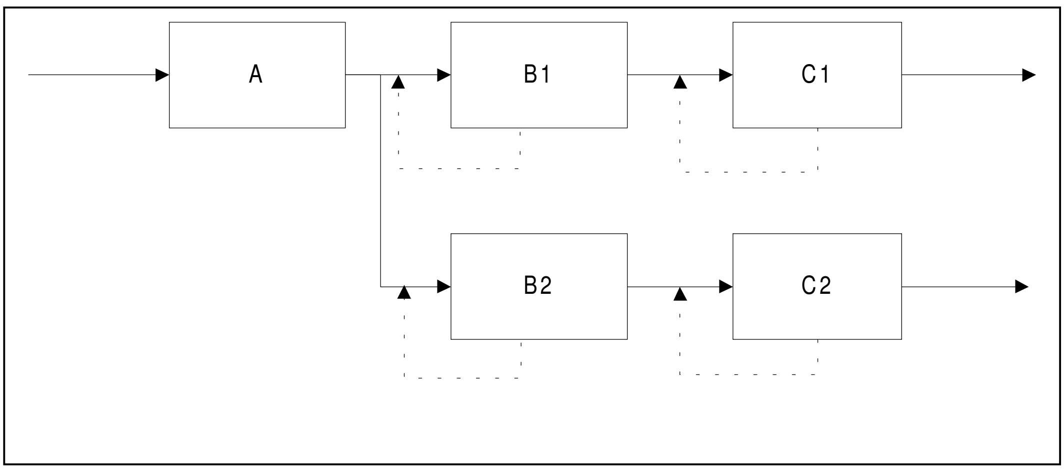


Figure 8-7: Split linear learning model.

The overall social learning goals aimed at in a VE should be broken down into their composite subtasks, with increased stimuli and options to the user as scenarios are built upon. Scenarios attempted in the SVEs will initially follow the linear model in Figure 8-7, progressing to a more complex one shown in Figure 8-8 where the order of sequences can be carried out in a multitude of ways depending on the choices made by the user throughout the whole learning process.

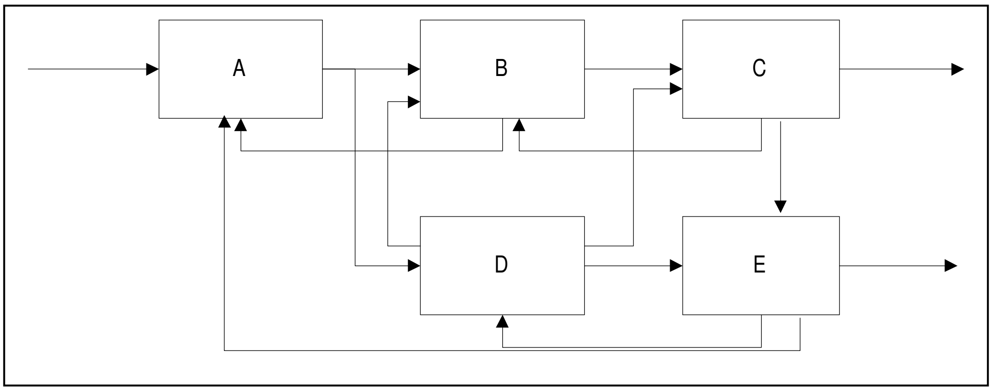


Figure 8-8: Complex Learning Model

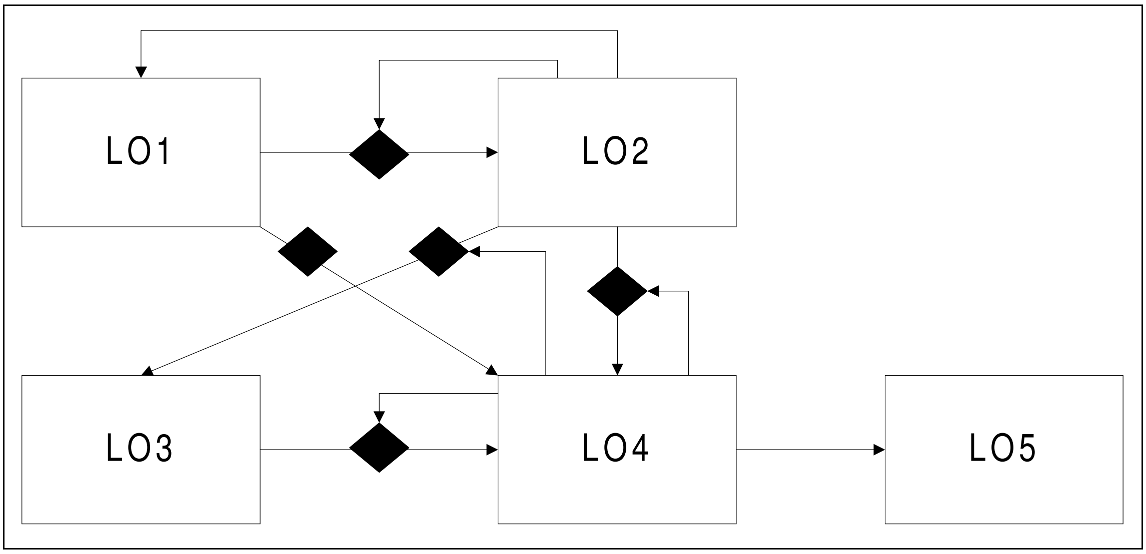


Figure 8-9: Non Linear Learning Model

Figure 8-9 explains the possible paths that users might take in non linear learning software. The model shows a number of learning objectives (LO), which can either require the user to navigate through or interact with the VE. The interaction could represent a physical action such as paying for food or a verbal action such as asking a question, and the interaction could be triggered either by clicking something within the VE itself or on a 2D interface, e.g. icon, outside the VE. The LOs shown represent the total that need to be met, though these may be active in part depending on the difficulty level selected by the teacher in a level based program, or due to the parameters set in an individualised program. Therefore teachers decide what LOs are active, which in turn determines the learning paths available to the user.

The arrows on the diagram show these paths between the learning objectives and the diamonds show where a choice or decision has to be made by the user. These learning paths can be navigations or interactions themselves which are important to the scenario, but are not LOs in themselves. Scaffolding can show what these paths are, which are available and how to successfully negotiate them or perhaps just take them there directly (e.g. LO4 • LO5). This automatic response inbuilt into the system could manifest itself as a movement of the user within the VE or triggering a specific event. The user could fail in their LO and be taken back to a previous choice or previous LO (e.g. LO2 • • or LO2 • LO1). The user could also perform an action, that takes them to a decision point (•), which then takes them to another choice which lies between 2 different LOs. The user would then need to complete a different choice and LO before getting back to where they originally were (e.g. LO4 • • • LO3 • • • LO4).

In each LO the program has to take into account how the user got there (which path they took), which other LOs have been successfully (or not) completed and in fact which LOs were available (effective level of difficulty) in determining what help is given and what the user must do to successfully complete that particular LO.

8.7.2 Code Structure

There are effectively three different ways in which the code can be structured within the VE to create learning scenarios (see section 7.3). Figure 8-10 shows the level based structure as used in the café and bus VEs, where within each learning scenario, functions X and Y are executed for specific difficulty levels. This can be shown in the simplified way that for each level, certain pieces of code are computed.

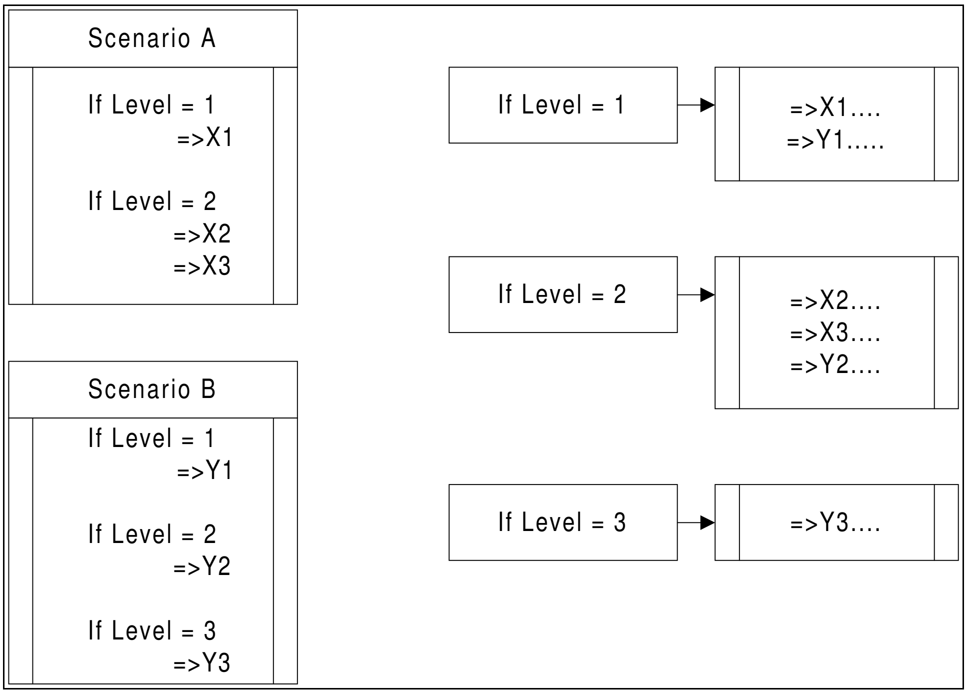


Figure 8-10: Level Based Code Structure

Figure 8-11 shows how code could be structured in a simple individualised VE such as the post office and bank demo VEs. It can be seen that the code is laid out exactly the same as for the level based VEs, except rather that a user choosing what difficulty level they are doing, they make parameter choices, A and B (eg. length of queue, availability of cashier) and from this the program works out the equivalent difficulty level.

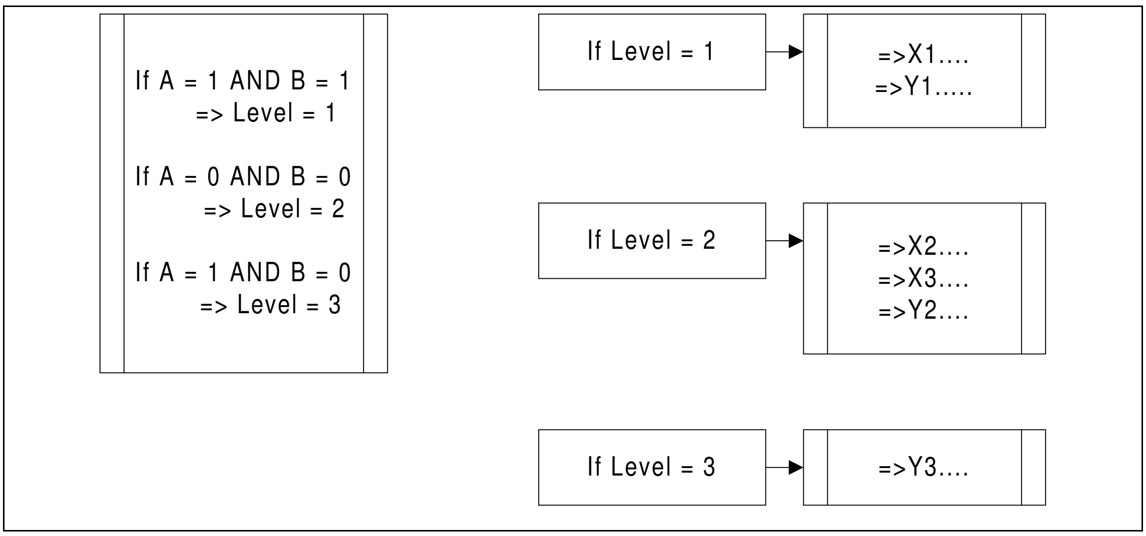


Figure 8-11: Individualised Code Structure using Levels

Figure 8-12 shows the modulised code structure of the individualised VE where in each scenario, functions X and Y are carried out based on the values of parameters A and B. This is a cleaner way of organising the code as more modules can easily be added without effecting existing ones. A downside could be that relatively straightforward sequences may require more complicated code structures than strictly necessary, especially if there are many parameters used across inter-related modules, where communication between them requires constant monitoring. It can be seen however that the code structure in Figure 8-12 is similar to the scenario level based code in Figure 8-10 with parameters rather than levels dictating what is happening. This meant that it was relatively straightforward to change the level based café VE into the individualise café VE, thus showing the importance of coding in modules (scenarios) as it is scalable (the ability to expand scenarios rather than allow greater numbers of people to use the system). Which method a programmer uses will largely depend on time, whether it is likely to be changed in the future and how the scenarios are controlled (through difficulty levels or parameters), though breaking the code into modules is always a good thing as has been shown here as unexpected change can be catered for more easily.

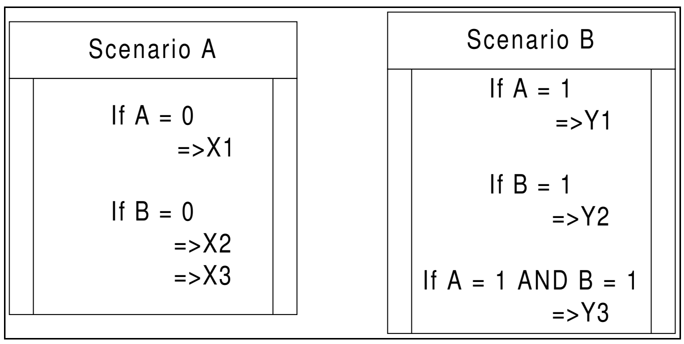


Figure 8-12: Individualised Code Structure – Module Based

8.8 Summary

Designing VEs to support learning for users with ASDs is not straightforward. Many issues need to be taken into account to ensure that the content and interface of the VE are suitable for the intended users and that it can be used as an aid for teaching in the classroom setting. This chapter has presented a detailed discussion of these issues and how they contribute to final design of the AS learning VEs. A summary of outcomes relating to each of the research questions addressed in this thesis is given below.

Q1: What is the role of a VE developer in a multi-disciplinary design process?

> The programmer occupies a central role as it is they who must mould the requirements of users, designers and other stakeholders into a product to meet those needs. They should therefore take a keen interest in the needs of the users and take part in user observations.

Q2: How can VEs be made usable to support learning for people with ASDs?

> There are a number of specific guidelines that can be used to make the content and interface of a VE usable. A user should be able to move around an environment easily and be where they want to be and interact with objects without hindrance. Environments should be meaningful to a user, but probably most importantly for a user with ASDs they should be varied enough to avoid rote learning and contain enough scaffolding to aid to guide the user through the learning task.

Q3: How can VEs be scaffolded to support learning in the classroom?

> VEs need to inform the user of what is required from them at any time, offer them help if they get stuck or offer options on what to do next. They should offer the maximum amount of help to a novice user with the amount of help being reduced as the user improves in ability. How a VE is used in practice is just as important as what is inside the VE itself and teachers play a very important role in facilitating its use. Ultimately, VEs should be customisable to meet the needs of the individual.

Q4: How can learning VEs be programmed so that they are robust and scalable?

> VEs have to be programmed modularly to account for change. To make a VE robust the programmer has to be aware that if anything can be pressed, activated or clicked at any time or simultaneously then it will, take this into account then watch the program being used and see what they missed

Chapter 9. Conclusions

9.1 Introduction

The previous chapter discussed the research in this thesis in relation to the main aims and objectives, regarding the design and development of learning VEs for social skills training for people with AS. This chapter restates the main contributions of this thesis to the aims and objectives of the research as well as contributions from a wider perspective to the research and development of learning VEs from the position of a programmer. Finally, recommendations for future research based on a continuation of the research discussed in this thesis or from parallel issues arising from this research shall be presented.

9.2 Contribution to Aims and Objectives

The main aims and objectives of this research, laid out in section 1.3, were met with the development of three VEs for teaching social skills to people with ASDs. These environments were two 'difficulty level' based café and bus VEs where the user had to carry out the same tasks of queuing and finding a seat, but in different contexts and a customisable café VE prototype that could have its layout and scenarios tailored to meet the needs of an individual. The VEs were developed with a user centred design approach in a number of iterative stages comprising evaluations with domain experts and users with consequent redesign and programming of the VEs. The level based VEs were developed as part of the multi-disciplinary AS research project with time constraints on producing usable applications, while the individualised VE was developed by the author independently as a continuation of the AS project research.

The contribution to the main aims and objectives presented in this thesis were as follows;

- Explored the role of the programmer as part of a multi-disciplinary research team from a programmer's point of view, looking at information they require from other members of the team to do their job and the order in which elements of a learning VE should be constructed and tested.

- Produced a summary of guidelines from the literature (see Table 2-1) on the design of learning VEs for people with AS. These guidelines were implemented in a practical situation, evolving through observations into further design recommendations (see Table 4-2)

- Guidelines from the literature and implemented in practice (use of VEs in a classroom) produced further guidelines for the scaffolding of VEs to aid learning with respect to people with AS (see section 5.8).

- Discussed technical issues, the role of the teacher and how to facilitate the use of VEs in a classroom setting (see section 8.5)

- Summarised guidelines from the literature on the requirements for individualised learning VEs (see section 6.3)

- Obtained information through expert review of prototypes for the recommendations for future individualised learning VEs, including the learning tasks, learning scenario context, issues for people with autism and features of VEs that can be controlled to aid learning (see section 7.6).

- Discussed different styles of programming and discussed their use depending on resources, time constraints and the desired application (see section 8.7).

9.3 Wider Perspective Contributions

Beyond the main objectives of this thesis, this section describes other contributions by reflecting on the research as a whole to gain a wider perspective of its implications. These are:

- Transfer of guidelines to mainstream education.
- Balance of skills in development team
- Flexible approach to application based research
- Level based v Individualised VEs
- Increasing availability of learning VEs for autism

9.3.1 Transfer of guidelines to mainstream education.

When developing VEs for a user group that has special needs such as people with AS, care and attention has to be applied in every aspect of the VE design to make it usable in a practical setting. It could be argued that more care is needed than for designing mainstream educational VEs and therefore there will be many guidelines produced for a special needs group that can be transferred to mainstream use to improve learning applications in that area.

9.3.2 Balance of skills in development team

The research team in the AS project was heavily weighted in favour of scientific researchers than on programmers. While this allowed for research into what the exact needs of users with AS were and whether they could understand that the VEs represented real world situations, development was still able to proceed after the end of the AS project by the author alone. The main difference in these two parts of the research was that the author acting alone did not have the time or support from autism professionals to evaluate the individualised VEs with users. Findings from the AS project indicated that learning VEs should be as realistic as possible with many more learning scenarios, especially if VEs are compared with current gaming technology. This clearly cannot be achieved with only just one programmer and the author believes that any future large scale development research project should have more people actually involved in producing the VEs with perhaps experts in different areas such as graphic designers, 3D modellers and network specialists.

This research has shown that a programmer can be an integral part of a research team and not just someone who executes other people's ideas. A person with both technical and research skills (especially if they are sole programmer on project team), can drive the research forward from an application perspective while understanding the needs of the user and the issues of using the application in practice.

9.3.3 Flexible approach to application based research

The continuous design, development and evaluation of VEs in an iterative process resulted in a new approach being taken in the makeup of the learning VEs, switching from level based VEs to individualised ones. Whilst this was not envisaged at the start of the research, the needs of the user were considered and further research was carried out in a new direction, whilst still meeting the requirements of the overall aim of the research.

9.3.4 Level based v Individualised VEs

While it has been shown that in the case of people with AS, that individualised learning scenarios are seen by teachers to be more useful than level based ones, the design elements of both are closely related and that depending on resources or the application to be developed, either method may be appropriate to use.

9.3.5 Increasing availability of learning VEs for autism

Just by developing learning VEs that can be used in a classroom setting rather than experimental prototypes tested in laboratory conditions has added to the collection of social skills learning applications for people with autism, which there is a paucity of, especially in terms of VEs and the unique attributes they offer. The VEs produced by the author are available online (www.virart.nott.ac.uk/asi) to anyone and is therefore available to be tested by parents, schools and other researchers in different settings or with different users.

9.4 Limitations of Research

9.4.1 Technology

The capabilities of Superscape VRT greatly affected how the VEs looked and performed. There is no one perfect building platform as each VR toolkit has its own strong and weak points. Superscape VRT allows the quick generation of complex functionality, but can be let down by appearances with a limit to the number of textures that can be used and the number of facets that are rendered at the same time, which particularly affects the look of virtual characters. These avatars are the VR objects most likely to look least like their real world appearance, which may affect how users perceive the VEs. There was no evidence to suggest that users were adversely affected by the look of the VRT characters, though any improvement in look should always be welcome, as greater realism should improve the sense of immersion. New toolkits such as VIZARD (www.worldviz.com) have much improved libraries of virtual characters that include a number of accurate facial expressions. The perception of how realistic a VE is could be influenced by a user's exposure to games consoles that have the most up to date graphics mostly due to the budgets available to the developers. Some art from these games has had some use in VEs, with Rizzo et al (2004) utilising elements from the console game Full Spectrum Warrior in their Virtual Iraq treatment for post traumatic stress disorder.

Another limitation of Superscape is that all objects have a bounding cuboid (see 3.2.3). This can affect the look of the environment with a tendency for a more blocky appearance, but can also affect the functionality of the program. Detecting the position of the user is usually checking to see if they are inside an invisible group which is a cuboid and this might not always be the most appropriate shape e.g. if the user tries to push into the curved part of the bus queue. The bounding cuboid around the avatars also mean that there is a limit to how close they can get to each other which would have an affect on looking at personal space issues and also results in there being small gaps between people in the queue which could be perceived as being a space that can be entered.

To run the VEs requires Superscape's Visualiser software to be installed which increases the potential for something technically to go wrong when setting up as it requires its own installation procedure that the developer has no control over.

There is no voice synthesis capability in VRT or any of the similar toolkits and so teachers cannot type in their own questions or responses for the scenarios. Equally there is no voice recognition and so responses cannot be given by users in natural language.

9.4.2 Participants

Since the research in this thesis carried beyond the end of the AS Interactive project there was no longer the support given by professionals which would allow for adequate user testing in the schools, though this was strictly not required in getting the individualised system up to a prototype state of readiness. However future work on the individualised VEs would ideally require this support.

The VEs developed for this research were designed and tested around users with AS and not on other special needs users. Testing would be required to ensure guidelines given in this thesis specifically for people with AS could be relevant for other special needs groups.

9.5 Future Work

This thesis has highlighted areas of research that require further investigation. In particular, the recommendations made in section 7.6 for issues relating to individualised learning VEs need to be implemented and tested. Contexts for learning scenarios, learning tasks and the ability to save individual user profiles suggested in Table 6-6 need to be applied. These elements then require testing in a practical environment such as the classroom to fully evaluate their potential. Areas suggested for individualisation, not immediately applicable due to limits in the technology or likely cost restrictions (in terms of what an educational institution is likely to pay for such software), such as dealing with emotions, recognising the intent of people through their actions or body language/facial expressions or the use of natural language in dialogue set up by a teacher (requiring voice synthesis or voice recognition) also require attention. These may not be useful from a cost effective point of view, but if the technology exists then issues relating to these areas can be researched so that knowledge is available for when such technology is more readily available/cost effective.

Another area that requires further research is the use of support materials with the learning VEs. Worksheets and tutorials were developed with the help of teachers for the bus and café VEs in the AS project by other members of the research team, but these were not evaluated in use. The difference between support materials used with level based and individualised VEs also requires investigation, though the author believes that the content for both would be basically the same, just organised in a different way to reflect the nature of the different styles of VE.

CVEs were initially researched as part of the AS project, but development of these applications were stopped due to technical difficulties and a lack of understanding about how to utilise them effectively as the issues relating to the learning in VEs and the scaffolding required to aid this learning had not been finalised. With the recommendations made in this thesis for SVEs, many of them could be adapted or suggest other recommendations on how best to use CVEs.

In this day and age, the expectations of users can be extremely high regarding the realism of a 3D environments due to exposure to games on the Xbox and Playstation2 and with the next generation consoles just around the corner, the threshold is bound to be raised again. The trouble of course is that these games are produced on budgets rivalling Hollywood blockbuster films with millions of dollars being invested while most educational software could not possibly compete on such a level as the number of units being sold is a tiny fraction compared to games. Whilst the level of graphics on educational programs will improve, not only will it lag behind games but the gap is likely to get wider. This could potentially be a serious issue unless a learning program can generate enough interest that it is adopted by every school in the land. Further research may be required on how differences in expectations affect the use of learning software and whether there are any techniques used in the gaming industry that can be applied in education in a cost effective manner.

9.6 Conclusions

Virtual Environments offer people with Autistic Spectrum Disorders the ability to learn and practice social skills in a safe environment that represents the real world. This could be beneficial to people with autism, allowing them to be aware of 'rules' for social interaction, even if they do not understand them. This may allow the maintenance of employment, though there is little or no evidence that these social skills are actually transferred (especially in a generalised form) to the real world. The point though is that in the role of the teacher in trying to teach social skills, they can only do their best with current knowledge and tools. The VEs developed in this thesis are hopefully tools that can improve the current state of teaching social skills to people with autism and used as a further step along the path to a truly effective strategy. The scaffolding of these environments to guide teaching are important elements of these applications and are building blocks that can hopefully be used in teaching environments in different application areas. The author's experience of developing scaffolded VEs from a technical and human perspective can hopefully be used to shape future learning VEs to be both usable and practical.

Chapter 10. References

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