

**Science and Mathematics Education Centre**

**Building a Virtual Classroom: An Education Environment for the  
Internet Generation**

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## DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any person except where due acknowledgement has been made.

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## ABSTRACT

This thesis examines the provision of learning environments that enable people to participate in high-quality learning experiences without physically travelling to classrooms and classes. New technologies enable the asynchronous web currently based on text, images, and video, to be extended to facilitate multi-channel synchronous communications. There is significant potential to enhance learning using the 3D worlds used for interactive gaming, populated by avatars representing the participants, and chat systems using text and audio channels. The purpose of this study was to investigate the development and use of 3D web-based learning environments. Staff and students from an Information Technology degree programme at one New Zealand Polytechnic participated in the study. The design and use of 3D web-based learning environments were integrated into one paper over six years. Data were collected from the teachers of this paper and the programme in which it was embedded. A survey instrument was used to collect data, along with artefacts from the software design and development plus the web-based environments created. Computer logs, and records of chat sessions were collected to enable analysis of the activities that took place in the new learning environments. Follow-up interviews were conducted with a sample of students after the completion of their study. Analysis of these data included collations of statistically significant relationships between environmental factors and the design features of the 3D web-based environments created. Results indicate that the 3D web-based environments were well received by the students and show significant potential for the future provision of learning environments. The technology has no negative impact on students' perception of their learning environment; however, it did not have the expected positive impact on their communications with peers or teaching staff. This research suggests directions for the future development and application of 3D web-based technologies to fully enable their potential to be achieved in educational learning environments.

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## GLOSSARY OF TERMS

3D World	A three dimensional space that can be navigated
Avatar	Representation of a person in a virtual environments
Blended (mode) delivery	Partially online, partially face-to-face
Control group	Group of students enrolled in the programme, but not enrolled in the paper being studied
Double credit paper	40 credit paper equivalent to two 20 credit papers from the degree programme
Human Computer Interaction	A field in Computer Science domain, focusing on the usability of software and computing devices
Main class world	The web-based 3D learning environment created by the researcher for each iteration of the research
MMORPG	Massively Multiplayer Online Role Playing Game, accessed through the internet using client software
Study group	Group of students enrolled in the paper being studied
Tutor	Lecturer or teacher of the class
Tutorial assistant	Student helper to assist the class tutor
Tutorial helpdesk	Student helpers, holding clinic hours to help students with technical assignment tasks

URL	Universal Resource Locator, the address of a web page
Web-based	Accessed via a web browser
Web-based online 3D environment	Similar to an internet MMORPG, but accessed using a web page, allowing multiple users to appear in avatar form and chat while moving around
Wire frame	Outline of 3D object drawn using lines. It is created by specifying each edge of the object where two mathematically continuous smooth surfaces meet, or by connecting an object's constituent vertices using straight lines or curves. The object is projected onto the computer screen by drawing lines at the location of each edge.

# CHAPTER 1

## INTRODUCTION

This is a vision of the kind of educational system that could become possible in an information society, a virtual network of learners, teachers, knowledge and examples of problems the learners want to solve. (Tiffin & Rajasingham, 1995, p. 16)

### 1.1 BACKGROUND

The internet has developed from an information publishing space to an interactive communication space. The internet now supports activities such as those involved in online games, which utilise the communicative and social aspects of computer-mediated interaction, offering multiple channels for communication which include voice and text chat plus movement and proximity awareness. Online games often use avatars to provision user embodiment within the virtual environment. These avatars fulfil several functions, including the means of interaction with the environment, the means of communication including gestures and awareness of others, the visual/social embodiment of the user. They also provide the means for sensing various attributes of the scene, providing a rich social context for synchronous online users.

This research aims to develop understanding of the issues surrounding the lack of progress with 3D virtual learning environments and further the development into web-based 3D virtual learning environments.

The concepts related to classes taking place through telecommunications links in virtual places and virtual classes were introduced in the book *In search of the virtual class* (Tiffin & Rajasingham, 1995). This book describes a new paradigm in education. It envisages scenarios where people do not use physical transport methods to travel to classes, rather they use information and communications technologies to create the classroom and the travel to class. It describes various technology options for a future where telecommunication replaces conventional

methods of travel for routine tasks and computers provide simulations of reality in which to conduct the tasks.

The concepts that education and learning can take place through telecommunications links are that learning takes place when students, teachers and knowledge are brought together to solve a problem; and that information and telecommunications technologies are able to provide a medium for communication between students, teachers and knowledge to facilitate problem solving and learning activities.

It is in the interaction of these four factors – learner, teacher, knowledge and problem in a particular context – that constitute the fundamental communication process that is education. (Tiffin & Rajasingham, 1995, p. 24)

The interaction of these factors is achieved through a communication process. In a conventional university the classrooms, lecture theatres and lecturers' offices provide spaces to bring these factors together, to enable the requisite interactions to take place.

The vision presented in this book is of a future where virtual reality presences travel to virtual representations of places, appearing and interacting as they would in the physical world. People in this scenario wear virtual reality suits and helmets to enter the virtual world, once there, they are fully immersed in the virtual reality. Telecommunications linkages and powerful computers are used to provide the simulations and communications. This vision of the technology is not yet a reality, the web-based 3D immersive online environments are currently the closest technology we have readily available using the internet to realise this vision.

The current evolution of the web has recently led to an expansion involving the integration of the concept of visibility, in addition to the established information publishing and interpersonal communication features of the web. Visibility means that the people accessing a web page can see representations of the other people accessing the same web page. While the addition of visibility threatens the web as an inherently anonymous medium, visibility increases the opportunities for the creation of communities of practice and communities of learners. The integration of

features enabling visibility in web-based applications is a possible future direction that will overcome the lack of progress to date with web-based 3D virtual learning environments.

The creation of any environment for learning, must consider the theories, frameworks that provide explanations, and models to facilitate understanding of the requirements for learning to take place. The theories provide insight into the activities that need to be provided in learning environments. This understanding is critical to the successful development of a learning environment.

Research investigating engagement associated with on-line gaming environments highlights the potential for these gaming environments to be used for other purposes. Work in the field of knowledge management and knowledge representation highlights the role of discussion and interaction in the dissemination and acquisition of knowledge. Contemporary developments in gaming, particularly interactive stories, digital authoring tools, and collaborative worlds, suggest powerful new opportunities for educational media (Squire, 2003).

Situating the development of educational environments in rich social contexts and combining powerfully motivating digital environments with a rich interpersonal communications medium provides an environment that has vast potential for education and learning. Together these form the bases for an emerging type of online education environment facilitating multiple interaction layers for the participants to create a compelling online learning environment.

A virtual classroom is both a group in which students and teachers want to accomplish goals and a community in which students and teachers exchange emotional support, information, and a sense of belonging (Hiltz & Wellman, 1997).

Vygotsky's Zone of Proximal Development, which requires learners to apply knowledge to problems that are in advance of those that they can solve independently also implies a community of learning. Knowledge is accessed through interaction with learning material, more advanced peers and with teachers (Vygotsky, 1978). This has significant implications that learning environments need to support collaboration. As this definition implies, it is through these interactions that learning

takes place, and therefore these interactions need to be facilitated by the virtual education environment.

The development of web-based 3D virtual learning environments is following the development of the online gaming environments, through the creation of 3D worlds where learners and teachers are represented by avatars. This research project is based on the premise that communication both between student peers and between student and teacher is a fundamental process involved in the act of learning. The facilitation of this learning process in an online environment is the primary focus of this research project.

## **1.2 STATEMENT OF PROBLEM**

When this research commenced the use of 3D virtual environments to provide learning environments had been experimented with for more than a decade (Tiffin & Rajasingham, 1995). In 2002 very little progress was being reported. They had not expanded at the predicted rates nor had they supplanted the physical classroom in providing the primary venue for learning at any level. In 2003 Tiffin and Rajasingham reported from their ongoing research in this field that “The dynamic communication that is possible in a conventional classroom has proved difficult to emulate” (Tiffin & Rajasingham, 2003, p. 24). This research aims to develop understanding of the issues surrounding this lack of progress and further the development of web-based 3D virtual learning environments.

Taking learning outside the traditional classroom does not remove the necessity for student-teacher communication or the need for student-peer communication. It does however make it harder to facilitate as the students and teachers are physically separated. Thus, it is difficult to integrate reliable and timely feedback loops in the communications mechanisms.

A virtual classroom is both an instrumental group - in which students and instructors want to accomplish goals - and a community - in which students exchange emotional support, information, and a sense of belonging. (Hiltz & Wellman, 1997, p. 46)

Newer developments in internet technologies have increased the capabilities of the web from an information publishing space to an interactive communication space. This research started in 2002 when web technologies were emerging to support social activities and features similar to those demonstrated in online games. The integration of these features into the web was later recognised as a trend that had started in 2001 and is now referred to as Web 2.0 or the read-write-web (Ullrich et al., 2008).

Many online games provision user embodiment for participants within a virtual environment using avatars to provide the means of interaction with the world, enabling awareness of others through the visual/social embodiment of the user, and the means of sensing various attributes of the world. These games include action forms to control the avatars such as keyboard actions and mouse movements. They also include real-time text-based chat as well as voice-based chat systems for. These emerging technologies had the potential to overcome limitations that had hindered the development of web-based 3D virtual learning environments to date.

### **1.3 OBJECTIVE OF THE RESEARCH**

This research project sought answers to questions on the use and usability of web-based 3D virtual environments for learning. The objective of this research was to develop and evaluate virtual education environments using the emerging technologies. The data collection and analysis centred on the engagement of the students in the environments, the impact on students' communications activities and the student perceptions of the environment for study.

Learning environment research is well established, with a history spanning three decades. It has established that there is a strong correlation between student outcomes and the student perceptions of their learning environment. It has also established that the learning environment has a significant impact on student learning. Originating from investigation into the psychological aspects of social environments, learning environment research has evolved to include many instruments to evaluate different types of learning environments. Each of these instruments measures the effectiveness of a specific environment for the learners and teachers who participate in it.

As this research commenced, learning environment research had started expanding into the evaluation and improvement of distance and web-based learning environments, with new instruments being developed for this purpose. This research project further developed these instruments for the evaluation of web-based learning environments through the inclusion of 3D virtual worlds.

As the study progressed a secondary focus emerged, analysis of the features proposed and created by the students involved in the research. As the environment was redesigned for each iteration of the research, the logs of usage from the web server and chat systems, plus the data collected from the survey instruments were collated. In addition, there was a large quantity of rich material produced in the actual design documentation and the software artefacts produced as part of the design and building process. The analysis of these actual designs and the software artefacts created during the development of the environments became a secondary focus for the research. The analysis of these environments utilized techniques from user-centred design and human computer interaction, focusing on user experience, user tasks, and features provided to facilitate user tasks. User-centred design is an iterative process focused on the development of usable systems, requiring the involvement of potential users of a system in the design process (Karat, 1996). The user-experience frameworks, defined in human computer interaction, draw on cognitive science and phenomenological approaches to analyse sensations and emotions as well as perceptions and behaviours (Swallow, Blythe, & Wright, 2005). The emphasis is on the user perceptions of the suitability, friendliness, and usefulness of a technology tool. Following the development processes defined by user-centred design: personas were identified; user experience goals and user tasks were identified and described. Then a design was created to enable the users to carry out the tasks while meeting the user experience goals. This was followed by the creation of a working prototype and then the evaluation of its use.

Thus, the objective of this research was to develop an engaging virtual education environment to promote the communications interactions necessary to provide a compelling online learning environment for two target groups. The first target group identified was the teenage and young adult group who have grown up using the internet as an information tool, communication tool, and recreational gaming environment. The second target group identified was the students who do

not have ready access to on-campus courses and who see web-based learning as a substitute for campus-based courses. These groups were identified as those who could potentially gain a significant advantage from the successful development of a web-based 3D learning environment.

#### **1.4 RESEARCH QUESTIONS**

This research sought answers to the following questions. The first was based on the focus of this thesis. This focus was to determine whether the virtual education environments developed were compelling, engaging, and provided an environment that enabled learners to experience success.

A. Is the environment, engaging, compelling, motivating?

The next group of questions provided guidance and insight into the processes that needed to be supported in the environment, initially to inform the design and later in the evaluation of each iteration of the research. These questions were used to evaluate whether the expected interactions occurred and had the expected effects.

B. What are the interactions between students, teachers, and tutors that contribute to the learning process?

C. How do these interactions facilitate the process of passing on knowledge and learning?

D. How are these interactions facilitated in the web-based 3D virtual education environment?

The last group of questions explored the effect of an inbuilt feature of the environment, its intrinsic visibility of the participants who were online. At the time this research commenced other online learning environments did not commonly include indicators that participants were online. A hundred people may all have been looking at the same web page, however, none would know of the others viewing the same page. This led to the “invisible student” phenomenon often referred to as lurking. This is where students read the material for an online course but did not add to the material through forum postings, leaving no trace that they were participating.

The web-based 3D virtual environments represent everyone viewing a particular world as an avatar so it is not possible to use a world without being represented in it.

- E. How do people build up the trust to talk to fellow students, to ask questions?
- F. Is lurking (observing without interacting directly with other participants) a common phenomenon?
- G. If lurking is common what makes a difference to the lurking phenomena?
- H. If lurking is common, does participation by lurking affect people's perspective of the environment?

## **1.5 OVERVIEW**

This research project was centred on building multiple web-based 3D virtual learning environments, using them for class activities in the delivery of a blended learning paper, while seeking answers to the research questions listed in 1.4. The structure and facilities provided in the web-based 3D virtual learning environments were based on traditional classroom-based environment and theory. The theory focussed on the nature of learning and theories of learning. In addition, communication and learning activities described in literature were used to assist in identifying features required in the environments. This theoretical base is discussed in Chapter Two.

The use of the online environment was analysed. These analyses were used to refined and redevelop the environment over eight years. The initial investigations started in 2002 and the initial prototype designs for the main class world were completed in 2003. This was followed by four iterations using the main class world to conduct classes. Since then there have been a further three iterations developing designs and prototypes that have not been used to conduct classes. This gave a series of different perspectives on possible designs, and a range of data showing how the technology was used as the environments evolved.

This research was conducted in a Polytechnic with a wide student base with a corresponding range of motivations for study. The students were from a variety of different demographic groups. The groups from the local community included school leavers, and mature students who were retraining. There were also international students from Pacific, Asian and European countries. The student ages ranged from school leavers in their teens, to people in their 40s and 50s. There were those who sought to advance their academic qualifications and those who sought a work ready qualification. Many started with lower level certificate courses to gain entry to the degree courses. Some just came for the third year courses seeking a Graduate Diploma in Information Technology.

The younger students were from the generation who are very familiar with internet tools having grown up using the internet as an information tool, communication tool, and recreational gaming environment. Some were students who did not have ready access to on-campus courses and who saw web-based learning as a substitute for campus-based courses. Other students did not have computers or internet access off campus. This led to a very diverse group with a wide range of needs as learners. This wide range of learner needs and attitudes needed to be considered in the designs. It was also important to avoid including technologies for their novelty value rather than their sound theoretical basis (Smith, 1997).

## **1.6 RESEARCH METHODOLOGY**

The research was based on a pragmatist view of research and the inquiry strategy followed a mixed method approach concurrently collecting both quantitative and qualitative data over the seven research cycles. The methods of data collection and data analysis combined elements of quantitative study with qualitative study integrating the information in the interpretation of the results. The research methodology was based on a participatory action research methodology, following a research by design process.

Designs for the web-based 3D virtual learning environments were created by both teachers and by students. The survey instrument design was based on the *Web-based Learning Environment Instrument* (WEBLEI), itself arising from a long history of learning environment research instruments (Chang & Fisher, 2003). The

software was designed and built on principles of human-computer interaction and best practice for 3D world design informed from the design of multiplayer online games. Evaluation methods followed both qualitative and quantitative methods. This approach provided multiple sources of data and multiple perspectives to be analysed and synthesised.

The environments were designed by staff teaching the papers involved in the research and their students. The papers were a third year capstone project, and a third year degree paper in Human Computer Interaction. The capstone project teams created the first and last prototype designs. The Human Computer Interaction papers were used to conduct the full trial iterations of the research. The designs produced were created as prototypes and used in the delivery of the classes. The design artefacts, such as personas and features incorporated in the designs were analysed, and the usage of the online environment was analysed. Attitudes to the use of the web-based 3D virtual environments were evaluated using a modified WEBLEI plus follow-up interviews with students who participated in the process. The responses of the students who were involved in designing and using the web-based 3D virtual learning environment were also compared with responses of students who were studying in the Bachelor of Information Technology programme but were not taking part in the Human Computer Interaction paper

The WEBLEI was developed in 2003 and draws on the long history of research instruments derived from the *Learning Environment Inventory* (LEI) (Fraser, Anderson, & Walberg, 1982). It has four scales: Access which covers emancipatory activities in three categories convenience, efficiency, and autonomy; Interaction, co-participatory covering six categories of flexibility, reflection, quality, interaction, feedback, and collaboration; Response, qualia covering six categories of enjoyment, confidence, accomplishment, success, frustration, and tedium; and Results, information structure and design activities covering organization, relevance, accuracy, and balance of learning materials. This instrument was been validated as internally consistent although the scales are “somewhat overlapping” (Chang & Fisher, 2003).

The WEBLEI was selected as a suitable instrument for this study as it is targeted on web-based and web-supported learning environments. Importantly, it is designed for the tertiary level. Minor changes were made to the WEBLEI wording to reflect the additional communications channels available through the 3D-world environments (Chard, 2006).

Chapter Three discusses the selection and customisation of the research instrument. Chapter Four discusses the research design used in more detail.

## **1.7 SOFTWARE**

The study started in 2002 with background research into the range of software tools available to build the online environment. The tool finally selected for this project was *Adobe Atmosphere*. This product enabled free access to the authoring programme for participating staff and students, the ability to embed the 3D virtual environment in a standard web page, the ability to link different worlds together through hyperlinks and the license to host a server locally on the Polytechnic campus. At the time of its selection, *Adobe Atmosphere* was in beta testing. It was originally developed by *Attitude Software* as *3D Anarchy* and bought by *Adobe Systems* in 1999. It was released as version 1.0 in October 2003, and then withdrawn from sale in December 2004. Although the software was no longer available for purchase, it was supported until December 2005, and continued to work for several more years. This research continued to use this software until December 2009 at which time current browsers stopped supporting the software plug-ins required to view the worlds in a browser. A participatory approach was followed with seven cohorts of students. The latter groups also evaluated the currently available tools and recommended products to use for the development of 3D virtual learning environments. A group project in 2010 recommended and implemented an *Open Wonderland* server and 3D immersive environment. Chapter Five discusses the selection of the software, including details of alternatives and reasons for the choice of software product in 2002/ 2003. Chapter Nine looks at future directions for web-based 3D virtual learning environments.

This research involved designing and building the 3D virtual worlds from a blank canvas. To develop the designs a participatory design approach was

employed. Participatory approaches also underlie the development methodologies associated with Human Computer Interaction and are at the heart of action research. Participatory design involves the inclusion of users within the development process actively helping in planning prototypes and setting design objectives. It contrasts with other development methods that seek user input after the initial concepts, visions, and prototypes exist. The participatory approach was pioneered and has been widely used in Europe since the 1970s, and now consists of a well-articulated and differentiated set of engineering methods in worldwide use (Greenbaum & Kyng, 1991; Muller, Haslwanter, & Dayton, 1997; Schuler & Namioka, 1993). The participatory approach has been used successfully in both information technology projects (Bodker, Gronbaek, & Kyng, 1993) and community projects (Hasell, 1987).

Students were involved in creating designs and implementing prototypes. These were linked into the main class world through teleports, and contributed parts of the world available to those participating in the research. These designs were also used to inform following iterations of the research as they offered a student perspective on appropriate designs for the learning environment. Participatory design naturally led to the research following a Design-Based Research approach (DBR Collective, 2003). As each iteration of the paper was running, a continuous improvement process was followed. This was used to make small changes in response to student requests or emerging issues identified through monitoring logs and participation. Between courses, major redesigns were carried out. These were based on reflection and analysis of the preceding course delivery. The goal was to increase quality and effectiveness.

The research has resulted in numerous designs. Each year the design of the main class world was altered using the ongoing research findings, to ensure improvements in each iteration. There were four iterations of the main class world design plus the students in each year created their own designs. Strong themes recurred in the student designs from one year to the next. The 3D virtual environments created by students nearly always reflected the physical environments used for learning, in either formal or informal settings. Occasionally, the students produced simulations or designs that reflected computer games, but the majority of the prototypes included classrooms with display screens for synchronous presentations or galleries of pictures. Very few prototypes contained material that

could be used directly as a source of information to assist learning, those that did usually included on demand tutorials.

The main class world evolved through the research. The first iteration was used as an introduction to the tools and was designed to provide a chat forum and a space to explore. Later iterations included, room for large gatherings, a soapbox and methods of displaying visual presentation material to accompany a person talking and a later site included movies of lectures, information about assignments and links to material stored in other web pages, embedded in the world. These proved to be too slow to use over the internet connections available to most students and the final iteration was a chat and exploration space embedded in the main web page for the course material.

The technology did not always work well, yet in spite of the technical issues during the research project, it always engaged the students. Learning in a cutting-edge online environment proved to be exciting and interesting to the diverse range of students participating.

## **1.8 SIGNIFICANCE OF THIS RESEARCH**

This research focuses on the development of 3D web-based environments for learning. It is relevant to all initiatives to provide online learning opportunities, and environments that support blended delivery of courses. It has particular relevance to the developers, researchers and users of 3D virtual environments for learning. It has advanced understanding of the design, development and use of these environments for learning.

The research contributes to the development of learning environment research through the modification of the Web-based Learning Environment Instrument (WEBLEI) to include 3D web-based learning environments. The development of this revised instrument will contribute to future research on similar learning environments. The revised instrument is also of interest to practitioners who wish to evaluate learner perceptions of web-based learning environments classes.

Theories of learning are explored, creating a series of frames for the evaluation of the 3D web-based learning environments. These frames include the

description of a continuum of learning theory from behaviourism through constructivism and cognitivism to connectivism. This continuum is used to analyse learning methods and learning activities that are provided in the environments used in this research. The second frame is the continuum of learning from pedagogy through andragogy to heutagogy which also contributes to the structures used to provide guidance on the design of the 3D web-based learning environment. The third frame used is based on the theories of interaction in learning. This perspective provided a reference for the multiple dialogs to be supported in the learning environments. These continuums were used extensively during this research. They were used for the evaluation of the designs. They were also used for the evaluation of the actual web-based 3D environments that were developed and used by the classes. The frames used for this research could be further developed and refined into useful tools for the evaluation of learning environments. Even without this further development, the frames are a useful tool for future research in this area. They are also relevant for the evaluation of other types of learning environments.

The research explores theories related to the efficacy of technology to create a sense of presence and facilitate the development of communities of learning. These contributed to the selection criteria for the software used to develop the web-based learning environment. They also contributed to the evaluation of the environments built and used. These criteria are a useful contribution for both practitioners and researchers engaged in projects requiring the evaluation of technology based tools for a similar purpose.

This research develops ideas about teaching and learning in virtual environments, knowledge building, and knowledge transfer. It develops ideas on the role of interpersonal communication in learning and the relationship to student perceptions of their learning environment. This is useful to both practitioners and researchers involved in the design of future learning environments as it provides insight into the role different communications technologies played in enhancing students' perception of their learning environments.

The learning environments developed followed a participative iterative development methodology. The students were active participants in the development of the web-based learning environment. The experience reported in this research will

provide useful information about the use of this process to others who embark on similar research projects and other situations that involve collaborative design projects.

This research provides guidance on the systems requirements for future developments of 3D learning environments. Evaluation of the 3D web-based learning environment design documentation reported in this research identifies activities to take place in the environments. These are categorised by those included in each iteration of this research and those that were not able to be provided with the technology available at the time. These feature lists will be useful to future developments of 3D learning environments, as they not only show the researcher perspective, they also show a student perspective of the requirements for web-based learning environments. A number of important enabling features were identified that should be included in future projects. The features identified provide a useful guide for future projects in this area.

This research investigated the usability, suitability, and usefulness of the 3D web-based worlds to provision learning environments. It reports metaphors used for the main class worlds and the student designs. These metaphors give insight into both the teacher and the student perceptions on the nature of the environments, which is useful to inform future developments. The research also reports user experience and usability goals identified by the researcher and participating students. These will be useful in the design of future 3D web-based environments. The information provided in this thesis on the use of the 3D worlds, the teacher and student perceptions of the usability of the worlds created, plus their recommendations for future features provide useful insight for research and development of these learning environments.

The virtual environment development tools are evolving at a fast pace, however some of the features that were considered an advantage with the *Adobe Atmosphere* software in 2002 are not included in the products available today, and some of the difficulties encountered during this research are still major risks with the current software tools available. As technology moves forward, some of the issues with network performance are being resolved as the new high-speed internet protocols become commonly available. However many of the issues encountered

with the technology used for this research remain and this research provides information on potential issues that may affect future research using 3D web-based technologies. The research also provides information on some of the strategies that can be used to mitigate the effects of using cutting edge technology in a learning situation. It raises a number of issues, related to technical design, to be considered fully when selecting the tools for future research. These issues include those around access through corporate networks and student access to suitable technology.

The research has identified a number of learning activities that should be supported in web-based 3D virtual learning environments. It has shown the use of these environments to be engaging and motivating for students. The use of these environments is applicable to both education settings and other collaborative environments where groups are working together on creative activities, particularly where members of the group are not able to physically travel to work.

The results have raised a number of questions that deserve further investigation both about the use of web-based 3D environments and the use of other communications technologies in teaching and learning situations. The research has identified important future directions in the use of 3D web-based learning environments.

## **1.9 LIMITATIONS OF THIS RESEARCH**

This research involved a small sample of students over eight years. It involved approximately 74 third year polytechnic students and one tutor over this time. The students were working in a blended learning environment. The first and last iterations of the research involved students working on capstone projects. The other six iterations of the research were limited to one third year paper in the Bachelor of Information Technology programme. The small sample size limits the generalisability of this research and to fully evaluate the effectiveness of web-based 3D virtual learning environments a much larger programme or even a campus wide approach would be required.

This research was conducted primarily by one senior Information Technology tutor. The tutor's role was to develop and deliver courses that showcased new technologies while helping students learn to develop usable software with the new

technologies. These students were all participating in a course designed and delivered by the researcher, then in the later part of this research the researcher was the Programme manager for all the Information Technology programmes at the polytechnic. With this in mind, it was necessary to be extremely careful not to let researcher bias influence the students' input and consequently the outcome of the analysis or findings.

The research combines quantitative and qualitative research methods however, the different data collection methods were spread over a number of years. The survey instrument used was the WEBLEI. This instrument was designed for use with web-based and web-supported courses in a tertiary environment. It was developed in Australia and has been proven to be a reliable instrument (Chang, 1999; Chang & Fisher, 2001b, 2003, 2004). The design data were collected over eight years, the log data was collected over the four years the software was used for class support and the interview data was collected by the researcher from participants in the classes covering three different years. The interviews were not conducted until after the students had graduated from the programme. This created a considerable time gap between some of the data collected.

The research was hindered by technology limitations as various technical issues arose during the research project. The short lifetime of the software was a blow as were technical difficulties related to the avatar synchronization and chat protocols. These required access to network ports often used by file sharing software. This caused some difficulties in enabling the software to work through firewalls on corporate networks. Network administrators were reluctant to allow the communications aspects of the software to work. This prevented some people from interacting with the software freely. When using the first versions of the builder software, it was still a beta product and therefore not completely stable. This did affect the user experience for some students who found the instability difficult to manage.

Once the released software was being used, the problem changed to the time limit imposed by the manufacturer for free use of the software. There was a limit of 30 days to learn the software, complete the design exercise, and build the prototype. Continuation of this research will require the selection of new tools as the software

was withdrawn from sale in December 2004, and was never available for purchase in New Zealand, in addition it no longer runs on current versions of the windows operating system and web browsers.

## **1.10 THESIS SUMMARY**

The following chapters are divided into four groups. Chapter Two presents the theoretical background for this research. It examines the literature on theories of learning, with regards to the activities that constitute learning, the organisation of these activities and the methods of engaging students in a web-based 3D virtual environment. It concludes with a summary of the applicability and role of the theories discussed in the design of the learning environments and the structure of this research.

Chapters Three and Four discuss methods of evaluating learning environments and the methodologies applicable to this research. Chapter Three discusses the development of learning environment evaluation instruments from their origins to the instruments being developed to evaluate web-based courses today. It explains the selection and customisation of the research instrument used for the collection of quantitative data for this research. A discussion of research methodologies suitable for evaluation of technology-based learning environments is presented in Chapter Four.

Chapter Five presents the software selection process followed and the choice of tool to create the web-based 3D virtual learning environment.

Chapters Six, Seven, Eight and Nine present analyses of the data collected during the research. Chapter Six, presents statistical analyses of the survey instrument data and relates this to the log data recorded during the research. Chapter Seven discusses analyses of the data from the designs created by the researcher and the students participating in the research. Chapter Eight discusses the interview responses and relates these to the Survey data analyses and the design data analyses. Finally, the research questions are answered in Chapter Nine. Furthermore, insights drawn from the research are presented and their significance discussed. Finally, recommendations for possible future research directions along with an acknowledgement of the limitations of this research are discussed.

## **CHAPTER 2**

### **THEORIES OF LEARNING**

Knowing is a human act. (McDermott, 1999, p. 105)

#### **2.1 INTRODUCTION**

This chapter presents an overview of the literature in several areas relevant to this thesis. The research aimed to develop understanding of the issues surrounding the lack of progress with 3D virtual learning environments and further the development into web-based 3D virtual learning environments. The literature review in this chapter is focussed on the theories of learning, social interaction, and relationships between teachers, learners, content, and the environment to facilitate learning. The creation of any environment for learning, must consider the theories, frameworks and activities that provide explanations, and models to facilitate understanding of the requirements for learning to take place. An understanding of these is critical to the successful development a learning environment.

There are many theories that are available to provide guidance on the design of new learning environments utilising emerging technologies. This is an emerging field that lies at the intersection of human learning, distance education, human-computer interaction, instructional technology, cognitive science, and information technology. This convergence of fields leads to issues and opportunities being scattered through a vast and uneven literature (Larreamendy-Joerns & Leinhardt, 2006).

Section 2.2 of this literature review looks at the theories of human learning on a continuum from behaviourism, through cognitivism, constructivism, and the emerging theory of connectivism. As the aim of the research for this thesis is to investigate new environments for learning, an understanding of relevant theories of learning is essential to the creation of an environment to facilitate learning.

Section 2.3 focuses on the literature on social interactions in learning and the contribution of the numerous dialogues between learners and other learners, content and teachers, to the learning experience. It is also concerned with the relationships of these dialogues to theories of human learning.

Section 2.4 discusses the relationships between teachers and learners understood through pedagogy, andragogy, and heutagogy. This is relevant as a guide to the learning activities and learning environment necessary to support a diverse group with a wide range of needs as learners.

Section 2.5 of this literature review looks at the concept of presence and the effect described as a “sense of being there” in a virtual world. The levels of realism and the perception of immersion in a web-based 3D virtual environment contribute to student’s perceptions of virtual learning environments. This is relevant to the research described in this thesis as an underlying factor in enabling the bringing together of teachers and learners to create an environment for learning.

Section 2.6 of this literature review, discusses the subject of the invisible student, often described as lurking, in online learning situations. The invisible student phenomenon causes concerns about student engagement and performance in online classes. This is relevant to the research described in this thesis as part of the research question relates to whether the multi-user environment has any impact on this phenomenon.

This literature review presents an overview of a number of areas relevant to the creation of new learning environments based on web technology.

## **2.2 CONTINUUM OF THEORIES OF HUMAN LEARNING**

The design process for new web-based technology used to create learning environments may be informed from established theories of human learning. These theories date from Aristotle’s discussions on remembering and perception identified as belonging to the tradition of behaviourism, through later theories of cognitivism and constructivism, and on to the emerging theory of connectivism.

### **2.2.1 Behaviourism**

Behaviourism discusses behaviours that can be observed and does not address the thought processes of the mind. Behaviourism is frequently traced back to Aristotle’s essay “On Memory”. This explained memory and recall as the results of sense perception. Remembering was explained as an unprompted recollection of

something previously experienced, whereas recall involved a mental search for an earlier experience. Based on this concept of recall he put forward his laws of association. These laws of association included laws of contiguity, similarity, contrast, and frequency. Aristotle used these laws to explain how we learn. Contiguity is explained as: when we think of one thing, we also think of things naturally associated with it. Similarity is explained as: when we think of a thing, we think of other similar things, and things which contrast, as we also think of things that are opposite. The most important is the law of frequency which states: that the more often events are experienced the stronger the association. An example often used is that events are naturally associated, such as thunder follows lightning (Hergenhahn, 2009).

Many other philosophers have followed in the behaviourist path defining laws of association and theories of memory. Hobbes (1650) arrived at the idea that the methods of reasoned decision, science, should be used in the scholarly study of human affairs, and that evidence was necessary for something to be known.

The first use of language, is the expression of our conceptions, that is, the begetting in one another the same conceptions that we have in ourselves; and this is called teaching; wherein, if the conception of him that teacheth continually accompany his words, beginning at something true in experience, then it begetteth the like evidence in the hearer that understandeth them, and maketh him to know something, which he is therefore said to learn: but if there be not such evidence such teaching is called persuasion, and begetteth no more in the hearer, than what is in the speakers bare opinion. (Hobbes, 1650, p. 71)

Hume (1748), proposed that the mind has its own principles, and that it is evident that there is association of ideas, ideas lead on from one another in a succession of thought. Hume defined three principles for the association of ideas, resemblance, temporal contiguity, and causality (Hume, 1748).

Brown (1820) defined laws of suggestion, preferring this term to that of association. These laws of suggestion are defined as resemblance, contrast and nearness, in place or time, relating these to the earlier ideas of Aristotle and Hume.

He supplemented this with secondary laws of length of time an object is dwelled on, liveliness or intensity of feeling, frequency, or repetition, freshness, and coexistence with another memory. He identified these secondary laws as intensifying the first laws. The sixth item in Browns' secondary laws was the referred to as the general powers of remembering. In this he proposed that as an idea was formed in the mind it was immediately being linked by the mind to associated memories and that these new groups of images were themselves new ideas as they had not existed in this combination before (Brown, 1820).

Bain (1855) also presented arguments for linking of memories through association and described circumstances that caused memories to adhere more rapidly and securely. The following is a general statement of this mode of mental reproduction.

Actions, Sensations, and States of Feeling, occurring together or in close succession, tend to grow together, or cohere in such a way that when any one of them is afterwards presented to the mind, the others are apt to be brought up in idea. There are various circumstances or conditions that regulate and modify the operation of this principle, so as to render the adhesive growth more or less rapid and secure. These will be best brought out by degrees in the progress of the exposition. As a general rule, repetition is necessary in order to render coherent in the mind a train or aggregate of images, as, for example, the successive aspects of a public way, with a sufficient degree of force to make one suggest the others at an after period. The precise degree of repetition needed depends on many circumstances, the quality of the individual mind being one. (Bain, 1855, p. 318)

Ebbinghaus (1885, 1913) pioneered experimental methods to measure rote learning and retention in memory using nonsense syllables. He demonstrated that memory is based on associations, and identified the now well known "forgetting curve" relating time to forgetting.

Behaviourism views the mind as a black box that responds to stimulus. The concepts of the thought processes occurring in response to stimulus are ignored. It concentrates on the study of explicit behaviours that can be observed and measured

(Good & Brophy, 1990). Some main influences in the development of the behaviourist theory were Pavlov with his experiments training dogs (Pavlov, 1927) and Watson (Watson & Rayner, 1920) who extended the conditioning experiment to a young child demonstrating the role of emotional responses to emotional stimuli. Harris (1979) questioned the validity of much of the later accounts of Watson's conditioning experiment proposing that it was not replicated in later literature and therefore was not generalisable despite the widespread citation. Thorndike (1932) also developed laws based on the stimulus-response hypothesis. He conducted experiments using animals and later moved on to human subjects. He believed that a neural bond would be established between the stimulus and response when the response was positive. Learning takes place when the bonds are formed into patterns of behaviour according to Saettler (1990). Skinner (1938) also believed in the stimulus-response pattern of conditioned behaviour. Skinner's work differs from that of his predecessors, in that he studied operant behaviour, this is a theory that deals with observable behaviour ignoring the possibility of any processes occurring in the mind. In his initial work using laboratory rats, he differentiated his work from the prior work of Pavlov and Watson in two ways: showing that behaviour is shaped and maintained by its reinforcing consequences rather than elicited as a conditioned or unconditioned response to stimuli, and he explained behaviour without reference to either mental or neurological events (Skinner, 1938).

I wanted a science of behavior that did not refer to the mind or to the nervous system. That was the theme of Chapter 8 in *The Behavior of Organisms* ... Once they have appreciated the value of the operant methodology, they are more likely to become allies in promoting behaviorism as the philosophy of such a science. (Skinner, 1989, p. 1)

Learning environments based on behaviourist theories commonly utilize methods that focus on teachers' efforts to transmit knowledge and students' efforts to accumulate knowledge. This is teacher centric and the students are viewed as passive receivers, with the use of repetition, a technique commonly attributed to behaviourism, to mitigate the forgetting curve.

### 2.2.2 Cognitivism

Cognitivism focuses on the inner workings of the mind. Cognitive psychology is also frequently reputed to be traced back to ancient the Greek philosophers, specifically Plato and Socrates. One of the major participants in the development of cognitivism is Piaget, who developed the major aspects of his theory in the 1920s. Piaget's ideas impacted on the views of education in the 1960s after Miller and Bruner founded the Harvard Center for Cognitive Studies.

Dreyfus and Dreyfus (1986) investigated cognitivism in relation to the creation of computer-based expert systems. Dreyfus (1990) traced the claims of cognitivism back to Plato and Socrates and defined it as:

Cognitivism is not simply a theory of cognition but, as the name, cognitivism, suggests, it is the strong view that all mental activity is cognitive -- that perception, understanding, learning and action are all to be understood on the model of fact gathering, hypothesis formation, inference making, and problem solving. (Dreyfus, 1990, p. 1)

Piaget believed knowledge occurs in stages and grows in complexity over time. Piaget's theory of human development can be outlined in terms of functions and cognitive structures. The functions are inborn biological processes that stay unchanged throughout our lives and are identical for everyone. The purpose of these functions is to enable the construction of internal cognitive structures. These cognitive structures change repeatedly as the child grows, and the child develops their understanding of the world through a process of acting and operating on it. "Through this process, a child's cognitive structures continually change" (Harwood, Miller, & Vasta, 2008, p. 29).

Cognitive theory recognises that a lot of learning involves associations created through contiguity and repetition. It also recognises the importance of reinforcement about the correctness of responses, a method that is usually associated with behaviourist theories. Cognitive theorists view learning as a process that involves the "acquisition or reorganisation of the cognitive structures through which people process and store information" (Good & Brophy, 1990, p. 229).

The learning methods commonly proposed by Cognitivist theory involve breaking tasks into steps and the delivery of information in steps. They propose that these steps should move from most simple to most complex. The methods also involve strategies to link new information to the learner's prior experience. They emphasise learning environments that assist students to make connections with prior experience and develop understanding through small incremental steps.

### **2.2.3 Constructivism**

Constructivist ideas are reputed to have origins dating back to the early 18th century. Von Glasersfeld (1989) attributed the first constructivist theories to the Italian philosopher Giambattista Vico. One of Vico's basic ideas as described by von Glasersfeld is:

... over and over he stresses 'to know' means to know how to make. He substantiates this by saying that one knows a thing only when one can tell what components it consists of. Consequently, God alone can know the real world, because He knows how and of what He has created it. In contrast, the human knower can know only what the human knower has constructed. (von Glasersfeld, 1989, p. 123)

Many other philosophers and researchers have developed constructivist ideas including Dewey (1910), Piaget (1971) and Vygotsky (1978, 1986). Constructivists challenge the views of behaviourists and cognitivists as personal meaning making replaces the acquisition of static knowledge. In a constructivist view of learning, learners are seen to reflect on and interpret experience according to their own mental structures. This integration of meaning is then represented as concepts to be expressed and transferred to new situations. From this perspective, learning is a process of adjusting the mental models learners have created of the world when they realize that they do not match a new situation.

In this view, learning is a constructive process in which the learner is building an internal representation of knowledge, a personal interpretation of experience. This representation is constantly open to change, its structure and linkages forming the foundation to which other knowledge structures are

appended. Learning is an active process in which meaning is developed on the basis of experience. (Bednar, Cunningham, Duffy, & Perry, 1992, p. 21)

Constructivists believe that learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of prior experiences, mental structures, and beliefs that are used to interpret objects and events. What someone knows is grounded in perception of the physical and social experiences that are comprehended by the mind (Jonassen, 1994; Jonassen & Duffy, 1992). Learners create meaning from their experiences. These meanings are individual and are separate and different from the meanings developed by others, even those that are participating in the same experience. Understanding is based not just on current experiences but the aggregate of all experiences, thus each person brings with him/her a cache of experiences that are brought to bear in a particular situation (Ertmer & Newby, 1993).

Von Glasersfeld and Piaget focused on individual constructions, whereas the socio-cultural approach emphasizes the socially and culturally situated context of cognition. Social interaction has an important role in the construction of knowledge. Social constructivists believe that knowledge is constructed socially using language (Vygotsky, 1986). Wertsch (1991) used the term sociocultural approach to mind when explicating the work of theorists, such as Vygotsky and Bakhtin into a theory of mind linking sociocultural contexts and speech genre with the interactions in formal instruction. Wertsch (1991) proposed that the social and psychological processes used in formal instruction be viewed from a perspective of speech genre. He stated that socialisation was the purpose of formal instruction and that this was the major reason for focussing on the sociocultural setting to analyse speech genres. He viewed formal instruction is a process of learning to speak particular genres and tones of languages and gaining an understanding of the specific contexts in which variations should and should not be used. In this view of constructivist theory, formal instruction is involved in the creation of a common construction through the use of a common language.

This view is extended by definitions that propose that social interactions are not only the vehicle for learning; they are also the vehicle for development, as growth comes through these interactions (Boudourides, 2003).

The learning methods often associated with Constructivist theories lead to environments where the teacher's role is a facilitator supporting students. The learning is facilitated by the teacher through mediation, modelling, and coaching. The learning activities are interactive and student centred and frequently project-based.

#### **2.2.4 Emerging Theory of Connectivism**

There are also emerging theories that seek to accommodate the affordances, potential new uses, and actions, of the new networked environments. These seek to better explain and contribute to the design of technology-enhanced learning environments. Connectivism is a new theory of learning and is a theory still in development. It has been proposed by Siemens (2005) and there has been little substantial criticism of it, though, as Siemens states, there has been significant discussion of the concepts involved (Siemens, 2006).

Connectivism (Siemens, 2005) is representative of the growing interest in networked theories of learning. Siemens proposes Connectivism as a learning theory for the digital age, since previous theories do not adequately account for learning when considering the knowledge requirements of the information age. Namely, how does learning theory change when information storage, processing, and recall are off-loaded onto external devices and through networked connections? Siemens defines Connectivism as:

Connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories. Learning is a process that occurs within nebulous environments of shifting core elements – not entirely under the control of the individual. Learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database), is focused on connecting specialized information sets, and the connections that enable us to learn more are more important than our current state of knowing. (Siemens, 2005, p. 6)

This view extends cognition from internal to external capacity. In this view of learning: networks including, neural networks, social networks, and technological

networks, represent a distributed view of knowledge. In the brain, knowledge is distributed through connections between different regions. Knowledge is also in the external networks we form, both social and technological. Knowledge is distributed through all these connections between individuals, groups, and devices (Siemens, 2006). This means that our network connections are not just sources of information, but the very connections that we make are part of our knowledge base. This focus on distributed external cognition through connections between learners and information sources adds an extra dimension to the established learning theories setting Connectivism apart from established theories of learning.

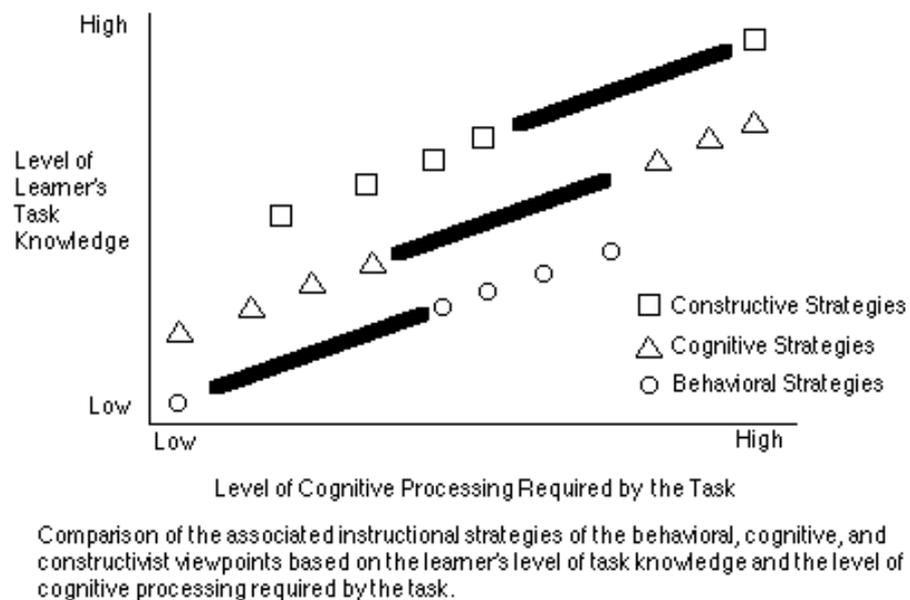
Behaviourism and Cognitivism position learning as an internal process and knowledge as an external entity, where learning occurs through the processing of input to arrive at an established knowledge goal. Constructivism places learning as both an internal process and a social process with knowledge as an external entity, where learning occurs through our interactions and knowledge is constructed through interactions. From the perspective of a Connectivist framework, learning occurs not only through social interactions, but also through interactions with and between networked nodes that may consist of people, places, devices, etc. Therefore, while a Constructivist would most likely see the network as solely a medium for social interaction, a connectivist would see the network itself as an extension of the mind. Learning is a process of connecting networked nodes and information sources (Siemens, 2005, 2006) to inform individuals' understanding and application of concepts and processes.

The role of the educator in a connectivist environment is seen as a curatorial role where the educators are expert learners themselves with advanced knowledge of a domain who guide, foster, and encourage learner exploration. Educators create learning spaces/environments in which knowledge can be created, explored, and connected. Learners are autonomous and their freedom to explore is unbounded, the curator-educator is the guide with the map (Siemens, 2008).

### **2.2.5 Summary of Learning Theory Continuum**

These theories of learning are not mutually exclusive, and have overlapping instructional strategies creating a continuum of learning theory. Ertmer and Newby

(1993) compared and contrasted behaviourism, cognitivism, and constructivism proposing that instructional strategy and the content addressed in instruction depended on the level of the learners. Ertmer and Newby (1993) believe that the strategies promoted by different learning theories overlap, utilizing the same strategy for a different reasons, and that learning theory strategies are concentrated along different points of a continuum depending on the focus of the learning theory and the associated level of cognitive processing required. They matched learning theories with the content to be learned:



*Figure 2.1.* Comparison of instructional strategies and level of cognitive processing (Ertmer & Newby, 1993, p. 69).

That is, a behavioural approach can effectively facilitate mastery of the content of a profession (knowing what); cognitive strategies are useful in teaching problem-solving tactics where defined facts and rules are applied in unfamiliar situations (knowing how); and constructivist strategies are especially suited to dealing with ill-defined problems through reflection-in-action. (Ertmer & Newby, 1993, p. 68)

Ertmer and Newby's description of the learning theories Behaviourism, Cognitivism and Constructivism as providing a continuum of learning strategies gives insight into the development of learning materials, and also into the interaction needs of learners. Connectivism as an extension of cognition into the network of

nodes can be viewed as adding to the end of the continuum by adding the dimension of distributed cognition, extending the mind through a network of nodes.

As these theories and associated methods are each part of a continuum of learning strategies that overlap and complement each other, the design of a new learning environment must incorporate methods that will enable a balance of strategies for learning to occur throughout this continuum.

### **2.3 INTERACTION IN LEARNING**

This continuum of learning theory may also be applied to the level of social interaction implied in each established learning theory with behaviourism having the least emphasis on interaction and constructivism the most, and the emerging theory of Connectivism moving interaction into the centre of understanding. The value of another person's perspective, usually gained through interaction, is a key learning component in constructivist learning theories (Jonassen, 1991), and in inducing mindfulness in learners (Langer, 1989).

Interaction is recognised as a key component in learning for a long time. John Dewey referred to interaction in 1916 as the defining component of the educational process that occurs when the student transforms the inert information passed to them from another, and constructs it into knowledge with personal application and value (Dewey, 1916). Bates (1990) argued that interactivity should be the primary criterion for selecting media for educational delivery. This long history of the study of the role that interaction plays in learning, is recognition of the critical role interaction has in defining and supporting both learning and education (Anderson, 2004).

#### **2.3.1 Social Learning, Social Development Theory**

Learning theories that emphasize conversation and social interaction include conversation theory (Pask, 1976), social development theory (Vygotsky, 1978), and social learning theory (Bandura, 1977).

Pask (1976) defined conversation theory based on a cybernetic and dialectic understanding of learning and cognition. The essence of this is that people learn

through conversation. More specifically, conversation is defined as a dialogue between two cognitive systems. Cognitive systems may be one or more persons, and may include knowledge artefacts. The dialogue may even be internal, as two aspects of one person engage in conversation. The two cognitive systems engage in a dialogue, recognising differences in perceptions, repeating the process until agreement is reached. The result is shared explicit or public knowledge that Pask called “entailment meshes”. This theory implies that conversation is essential for learning to take place and that this requires two participating cognitive systems aiming for a mutual understanding.

Vygotsky's theoretical framework is based on the premise that social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) proposed that a child's cultural development occurs in two stages. In the first stage the function appears as an interpsychological process and then it develops as an intrapsychological process. This implies that cultural development is dependent on a social context. This context enables the child to develop the first stage of a function at a social level, between people before the function is then developed inside the child. This two-stage model of social development of higher functions applies equally to the development of: voluntary attention, logical memory, and the formation of concepts. Relationships between individuals are necessary for the development of all the higher functions. (Vygotsky, 1978)

Vygotsky is also known for the development of the idea that the potential for cognitive development depends upon the Zone of Proximal Development (ZPD). The ZPD is the difference between what learners can do without assistance and what they can do through social interaction with more experienced peers.

the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

This is a well-recognised often-quoted theory on the role of interaction in assisting learning. This definition implies that any system for learning involves learners, knowledge, problems, and a teacher or more advanced peer to assist the

learners to solve the problems that they cannot solve themselves. This involves two-way communication between the learners and teachers in an environment that contains the knowledge and the problems plus the learners and the teachers. This is required since when the learners are attempting to solve problems through the application of knowledge, the teacher assists to create the solutions. This has the significant implication that learning environments should support this collaboration. This means that the interactions between learners and problems, learners and content, and learners and teachers or more advanced peers should be facilitated. To enable this collaboration and the creation of ZPD's in a virtual learning environment all of these interactions need to be facilitated.

Bandura (1977) developed social learning theory from experimental psychological studies. It is a general theory of human behaviour derived from investigations in the field of social psychology demonstrating how children learn and imitate modelled behaviours. Bandura argued that people learn from observing role models in day-to-day life. He observed that if people had to rely only on the results of their own actions to learn what the effects of these might be, learning would be exceedingly dangerous and very hard work. Luckily, most human behaviour is learned from the observation of others actions and the effects these have. The actions of others act as models that are then used to form ideas of how new behaviours are performed. He described these models as coded information that are used as guides for future actions.

This theory implies that learning occurs in all social settings, and the modelling provided by teachers and other students is a very important part of a learning environment. Social learning theory covers memory, attention, and motivation. It spans behaviourist, cognitivist and constructivist perspectives on learning. This work is related to the social development theory of Vygotsky (1978) who also emphasizes the central role of social learning.

### **2.3.2 Interaction**

Interaction is further defined by Moore (1989), as having three types that occur between learner and instructor, learner and content, and learner and learner. This definition was extended by Anderson (2003) to include: learner and

environment, instructor and instructor, instructor and content, and content and content. The instructor to student interactions are critical to cognitive and behaviourist learning theory based activities. The student-student interactions are critical for constructivist based learning activities. In addition, student to student interaction is critical for the development of the skills needed for collaborative and cooperative tasks (Anderson, 2004).

Garrison (1989) argued that dialogue and debate are essential for learning, explicitly placing sustained real two-way communication at the core of the educational experience. The reason given is that these forms of two-way communication allow learners to negotiate and structure personally meaningful knowledge. Teaching necessarily transmits societal knowledge, but a rounded learning experience needs to foster critical analysis processes in order to bring personal perspectives to bear and create new understanding for both the teacher and student.

Modern constructivist theorists stress the value of peer-to-peer interaction in investigating and developing multiple perspectives. Peer interaction is a critical component in the development of communities of learning (Wenger, McDermott, & Snyder, 2002). Communities of learning enable learners to develop interpersonal skills, and to investigate tacit knowledge shared by community members as well as engaging in a formal curriculum of studies.

Work on collaborative learning also illustrates the potential gains in cognitive learning tasks, as well as increases in completion rates and the acquisition of critical social skills in education (Slavin, 1995). Work by Damon (1984) and others related to peer tutoring illustrates the benefits to both the tutor and the learner that can result from a variety of forms of “reciprocal” teaching

Interactions between participants in a learning environment serve a variety of functions in the educational transaction. Garrison and Shale (1990) defined all forms of education, including that delivered at a distance, as in essence interactions between content, students, and teachers. Laurillard (1993) constructed a conversational model of learning in which interaction between students and teachers plays the critical role. Sims (1999) described dimensions of interactivity in a

learning environment. These dimensions are learner control and communication. Learner control is further defined as the adaptive capacity of the learning environment and resources to react to learners' responses. Communication is further defined as the extent to which the integration of communication or conversation is integrated in the learning environment.

Garrison (2009) argued that interaction is essential to learning:

A dialectic process dynamically supported through collaborative exchanges with another person who knows more than the student and who has a wider, more balanced view of what is being learned - in other words a teacher - may be irreplaceable for meaningful and worthwhile learning. (Garrison, 2009, pp. 96-97)

In addition, interactivity is fundamental in the creation of learning communities and communities of enquiry as described by Lipman (1991). Situated learning is described by Lave and Wenger (1991) and community of practice described by Wenger (2001) and Wenger, White and Smith (2009). Each of these focus on the role of interaction and community in learning, describing how members of a learning community both support and challenge each other, leading to effective and relevant knowledge construction. Wilson (2001) has described participants in online communities as having a shared sense of belonging, trust, expectation of learning, and commitment to participate and to contribute to the community

The value of other people's perspectives, usually gained through interaction with another person, is a key learning component in constructivist learning theories (Jonassen, 1991) and in inducing mindfulness in learners (Langer, 1989).

### **2.3.3 Summary**

Interaction in learning environments has been defined as occurring between, learners and content, learners and learners, learners and teachers or instructors, teachers and teachers, plus teachers and content. Each of these interactions is described as essential for learners to create meaning and understanding. The dialogue between learners, and other learners, content and teachers all contribute to

the learning experience. A web-based 3D virtual learning environment must be designed to maximise these interactions for optimal learning to take place.

## **2.4 THE PEDAGOGY, ANDRAGOGY, HEUTAGOGY CONTINUUM**

There are theories that guide the development of learning environments specifically developing the understanding of adult learning in contrast to the study of children's learning.

### **2.4.1 Pedagogy**

Many in education use the term pedagogy to refer to all teaching; however, pedagogy concentrates on child learners, excluding the needs of adult learners. Pedagogy is a word derived from the Greek word *paidagōgeō* meaning to lead the child and literally means the art and science of teaching children. Discussions on pedagogy centre on the relationship between teacher and learner with a teacher-centric view that the teacher determines what the learner should know and how it should be learned. The result is a teaching and learning situation that actively promotes dependency on the instructor (Knowles, 1984).

### **2.4.2 Andragogy**

Discussions of andragogy started when Knowles (1970) popularised the term as the study of the specific needs of adults in learning. Knowles defined the term as "the art and science of helping adults learn" (Knowles, 1980, p. 43), suggesting important changes in the way in which educational experiences for adults should be designed with an emphasis on self-directed learning and cooperative guided interactions between teacher and learner. This approach contrasts sharply with pedagogy which is the teaching of children.

The model of andragogy put forward by Knowles (1980, 1984) is based on five assumptions about learners derived from his own observations, all of which have some relationship to concepts of a learner's ability, need, and desire to take responsibility for their learning. These five basic concepts of andragogy are that adults are self-directed learners, adult learners bring a wealth of experience to the educational

setting, adults enter educational settings ready to learn, adults are problem-centred in their learning, and adults are best motivated by internal factors (Knowles, 1980, 1984).

Pedagogy and andragogy have, more recently, been viewed as a part of a continuum at opposite ends of a spectrum, with dependent child learners at one end and self-directed adult learners at the other. In 1984, Knowles stated that he now viewed andragogy and pedagogy as being on a continuum, noting that there were times when either approach might be appropriate based on circumstances and needs of the learner (Knowles, 1984).

### **2.4.3 Heutagogy**

Heutagogy further expands this continuum with the addition of learner determined learning. Heutagogy is the study of self-determined learning and may be viewed as a natural progression from earlier educational methodologies focusing on knowledge sharing rather than knowledge hoarding (Hase & Kenyon, 2000).

Heutagogy is not a departure from andragogy; it is an extension of the pedagogy andragogy continuum that incorporates self-directed learning. The idea that pedagogical approaches to learning were perhaps inappropriate for adults was an important advance in the discussion of adult learning. Andragogy, or approach to teaching adults, was quickly adopted by educators, trainers, and academics. Heutagogy is a natural addition to the continuum.

Heutagogy is learner centred and includes aspects related to capability and learning how to learn; referencing action learning processes such as reflection, and environmental scanning as understood in Systems Theory; and valuing experience and interaction with others. It goes beyond problem solving by enabling proactivity.

we have been able to document how doctoral students undertaking action research theses have progressed from pedagogical, then andragogical to heutagogical learning in the course of their research ... This has been one of the few research projects conducted to investigate the relevance of Heutagogy in understanding the learning experience. (Hase & Kenyon, 2007, p. 113)

A heutagogical approach recognises the need to be flexible in learning where the teacher provides resources but the learner designs the actual course he or she might take by negotiating the learning. Thus, learners might read around critical issues or questions and determine what is of interest and relevance to them, and then negotiate further reading and assessment tasks. With respect to the latter, assessment becomes more of a learning experience rather than a means to measure attainment. As teachers, we should concern ourselves with developing the learner's capability not just embedding discipline-based skills and knowledge. We should relinquish any power we deem ourselves as teachers to have (Hase & Kenyon, 2000).

#### **2.4.4 Summary**

This research project was conducted in a polytechnic with a very wide range of learners. This very diverse group had a wide range of needs as learners. This wide range of learner needs and attitudes needed to be considered in the design for the web-based 3D virtual learning environment. A useful framework for this consideration was this understanding of the pedagogy, andragogy, heutagogy continuum which provided guidance on the design of learning activities and provided a focus to create an effective design for the 3D web-based virtual learning environment.

#### **2.5 PRESENCE**

Presence, in the sense it is being discussed here, is a short form of tele-presence. This refers to the sense of being there in a virtual world, and the state of mind when the mediating technology has retreated into the background of perception. The aim of research investigating presence is to investigate the technologies and the effect of the technologies that contribute to the experience of presence in virtual realities. Web-based 3D virtual worlds are a form of virtual reality, albeit of a lower fidelity than fully immersive virtual realities entered using sensory suits and caves.

The concept of presence is a concept separate from emotional engagement and different from imagination. Presence is the feeling we get from attending perceptually to the present world (in both time and space) outside ourselves.

Presence is the subjective sensation of being there in a mediated environment yielding a perceptual illusion of non-mediation. (Waterworth & Waterworth, 2003, p. 10)

Presence in virtual environments has been categorised into personal presence and co-presence. Personal presence is the perception of being there yourself while co-presence is the perception that others are there with you (Casanueva & Blake, 2000). Presence integrates the additional perceptual information gained from being there with others. Awareness includes additional state information, such as whether others are currently active or idle and the nature of the task in which they are currently engaged. A simple example of awareness is when using an instant messaging client there is a “buddy list” which lists the user’s “buddies” and their current state as online, busy, or offline.

The closer the mediated environment can facilitate the perceptual illusion of being in an external sharable world, generating the sensation of being there, and an illusion of non-mediation, the greater the opportunities for communities to form.

Presence is defined as the experience of being engaged by the representations of a virtual world (Lombard & Ditton, 1997). Much of the research on presence has focused on technologies that use a variety of sensory inputs (e.g., visual, auditory, haptic) to create a simulacrum of a real environment, a virtual reality that mimics perceptions in the physical world (Biocca, 1997; Heeter, 1995; Kim & Biocca, 1997; Lombard & Ditton, 1997; Witmer & Singer, 1998)

Lombard and Ditton (1997) discussed six conceptualizations of presence. The first is a sense of social richness, psychological closeness, or immediacy, the feeling a person gets from social interaction. The second is a sense of realism. This includes social realism, the virtual environment looking and feeling like real life. It also includes another dimension, perceptual realism. This is where the “objects and people look and sound like one would expect if they did in fact exist”, for instance a scene from a science fiction film may be low in social realism but high in perceptual realism. The third is a sense of transport. This is a feeling of sharing a common space with another person, a feeling as though “you are here” or “you are there” or “we are here together”. The fourth is a sense of immersion through senses or the

mind. This is often measured by the number of senses that receive input from the virtual environment. The psychological component is sometimes described as a feeling of being absorbed, engaged and engrossed. The fifth is a sense of being social actors within the medium. These are social actors who have interactivity and control, not passive viewers. The sixth and last conceptualisation of presence is a sense that the medium is a social actor. This social actor is capable of evoking social responses to the medium as a whole.

Mania and Chalmers (2001) describe a comparative memory study between a real 15-minute seminar, an audio only simulation and two virtual simulations of the real experience, one displayed on a typical desktop monitor and one on a head mounted Device. The desktop display environment was a 3D avatar based environment similar to that proposed for this research. The experiment design included evaluation of two sets of recall data, questions related to the actual information presented in the seminar, plus questions related to the spatial perception of the participants related to the seminar room itself. The presence questionnaire revealed no significant difference between the three different technological conditions although there was a significant difference between the individual technological conditions and the real seminar. They reported that there was no statistical difference between the information recall task or the spatial recall task between the real and the desktop condition, however there was a statistically significant difference between the real and the audio only, and the head mounted device conditions with these two technological conditions scoring significantly lower on both sets of memory recall questions.

Contemporary multiplayer online games utilise communicative and social aspects of computer-mediated interaction. The interaction forms are actions that can be perceived by the players including interactions between players, and between players and the game software. These interaction forms are used to communicate actions to the players including the initiating user. The interaction forms enable awareness and auralisations within the game environment (Manninen, 2003).

Even multiplayer online games have fundamental problems in supporting rich social activity. Bowman and Hodges (1999) point out that the current applications within the entertainment sector (i.e., computer games) do not usually require any

complex interaction between the user and the system. Although the user may be interacting frequently, the interactions are mostly simple in nature. Application of the Habermas' (1984) Communicative Action Theory (CAT) framework has been used to identify the following categories of interaction manifestations.

(1) avatar appearance, (2) facial expressions, (3) kinesics, (4) oculosics, (5) autonomous / AI, (6) non-verbal audio, (7) language-based communication, (8) spatial behavior, (9) physical contact, (10) environmental details, (11) chronemics and (12) olfactics. (Manninen, 2003, p. 1)

Research into the quality of avatars and graphical representations in the environments suggests that a combination of higher realism, plus avatars with increased gesture control and movement methods contribute to the sense of realism in web-based online 3D worlds.

Casanueva and Blake (2001) reported:

We found that there was a significant difference in the co-presence scores between avatars of different appearance. The realistic human-like avatars produced a greater sense of co-presence than cartoon-like avatars, which in turn produces a greater sense of co-presence than unrealistic avatars. We found that avatars having gestures and facial expressions produced a significantly higher level of co-presence when compared to static avatars. We also found that realistic human-like avatars, with or without gestures and facial expressions, did create a higher sense of co-presence when compared to unrealistic avatars without any body movement. (Casanueva & Blake, 2001, p. 16)

Anderson, Ashraf, Douthier and Jack (2001) investigated the use of a 3D world virtual conferencing room for meetings. This activity has many similarities to the seminars and other discussion-based classroom activities often conducted in learning situations. This study used a simulated conference room for participants to have meetings. A participative approach was followed through three phases of research. Their findings show that following a short period to acclimatise to the environment the shared conference space can induce a strong sense of involvement

and presence for the participants. They also give guidance for the design of optimal shared space conferencing systems. This advice includes the need to be selective about realism, the importance of view control and avatar animation in support of speaker identification. They also highlight the need to enable users flexibility in turn taking and gesture control, and finally they emphasise the benefits of symbolic acting.

When developing an environment that is capable of producing the sense of presence described above, it should include as many sensory channels as possible and have provision of high fidelity graphics, and realistic animated avatars. The research described in this thesis used the technology available at the time that provided as many of these facilities as practicable in the virtual environment.

## **2.6 INVISIBLE STUDENT PHENOMENA IN ONLINE LEARNING**

The invisible student, is a phenomena frequently reported in online learning. This phenomenon is often referred to as lurking behaviour. Lurking is defined by Oxford Dictionaries (2011) as “read the postings of an Internet message board or chat room without making any contribution”. Other meanings are also listed with much more negative connotations “be or remain hidden so as to wait in ambush for someone or something”, “(of an unpleasant quality) be present in a latent or barely discernable state, although still presenting a threat”. The inference from this is that lurking is not a behaviour that should be encouraged. From this, lurking or invisible students in online learning contexts may be defined as those students that read the web pages, postings in forums, chat rooms, and message boards but do not contribute to the discussions. Lurkers as a category of online participant may be perceived as freeloaders, who benefit from an online community’s wisdom without giving anything back (Preece, Nonnecke, & Andrews, 2004).

Interaction is a component of online courses that has received a lot of attention, with the assumption that interaction is a critical part of learning (Berge, Collins & Dougherty, 2000; Jung, Choi, Lim, & Leem, 2002; Sims, Dobbs, & Hand, 2002). The focus on interaction and learning communities has become so strong that some have suggested that lurking is a negative activity that takes away from an online learning environment (Rovai, 2002).

An alternative perception is that those who are lurking and not actively participating may be learning through their observations of others' interactions and therefore be legitimate peripheral participants (Lave & Wenger, 1991). Learning by observing others engaged in a learning dialogue may actually be ideal for learners who are grappling with a new topic as it allows them to focus on the content taking away the pressure to perform or articulate (McKendree, Stenning, Mayes, Lee, & Cox, 1998).

In other instances, students who lurk at one point may be active message posters in other threads or may simply return to the discussion board to re-read and reflect.

Because some choose to be less participatory does not necessarily mean they are less engaged in meaningful learning. Indeed, it could be argued that the "overactive" online students (i.e., those who are constantly inputting words) do so at the expense of a more reflective and less visible learning process in which their silent peers are actually more fully engaged. (Beaudoin, 2002, p. 153)

Some researchers have discovered that there are many reasons why people lurk. They have identified that some are indeed unsociable or even selfish, but many are not, and some even have an altruistic reason for their lurking behaviour (Beaudoin, 2002; Dennen, 2008; Nonnecke & Preece 1999; Preece, et al., 2004).

Dennen (2008) reported that pedagogical lurking, defined as "temporary situational or topical lurking in a class context" (Dennen, 2008 p. 1631) might just be part of regular online class participation, as participating students indicated, that for a variety of reasons, they did sometimes log in just to read messages. Although there is a tendency by educators to encourage active posting and contributing to online discussions, there is little value for students in engaging solely in posting, while never engaging in reading and reflecting (Dennen, 2008).

The invisible student in online learning situations has a corollary in traditional classroom learning, the student who sits silently all the way through class sessions, who may even look bored, but who achieves well on assessments (Dennen, 2008).

The invisible student phenomena is a feature of web page based online learning. The standard browser-based web, commonly referred to as Web 1.0 provides for multimedia publishing of information using text, image, video, and sound. This primarily facilitates the storage of information for asynchronous communication. This was the behaviour defined in the original proposal document for a distributed hypertext structure for information management (Berners-Lee, 1989). When this research commenced in 2002 the web was at an early stage of development, the synchronous methods of interaction now defined as Web 2.0 were very rare as the technologies were only just starting to emerge. The standard web-browsing interface only promoted interaction between individual people and previously published material. Even in the parts of the web designed to enable people to interact, such as forums and message boards, the material was published then left for asynchronous viewing.

It is an irony of the Web that although numerous people may be in the same virtual place at the same time, an important ingredient for social interaction, web users are never aware of others. In effect, they roam the web in solitude - lone wanders in a deserted world. (Walker & Lambert, 1995, p. 9)

Even short messaging text-based chat systems are not fully synchronous and there is often a delay between messages being submitted and displayed, and when chat logs are being saved and made available as history they are being published for asynchronous consumption. The advantage of chat systems is that they include awareness mechanisms that allow groups to see other participants online at the same time as themselves, although most provide the ability to lurk, allowing participants to appear offline when they are actually present and observing.

The web-based 3D virtual learning environment is a synchronous environment in which all participants are visible as avatars to the others present. Although this feature will prevent the invisible student phenomenon occurring within the environment it will not prevent legitimate peripheral participation, attending, listening, and reading without contributing. The ability to differentiate between legitimate peripheral participation and non-participation may be able to contribute to the discussion on the lurking phenomenon in online learning.

## 2.7 SUMMARY

The concepts of the virtual class and global virtual university identified in Chapter 1 as the motivation for this research were described in the book *In search of the virtual class: Education in an information society* (Tiffin & Rajasingham, 1995). The global virtual university concept is premised on the belief that it is possible to create an education environment and populate it using information technologies. The proposition is that it is possible to provide sufficient channels for the communication necessary between the learners, content, and teachers using Information and Communications Technology linkages.

The research into presence suggests that to develop a web-based 3D virtual learning environment that is capable of producing a sense of presence it should include as many sensory channels as possible and have provision of high fidelity graphics, and realistic animated avatars.

The research on the invisible student phenomenon suggests that the enforced visibility of participating students inherent in web-based 3D virtual environments, through the use of avatars to represent participants, will enable investigation of the effects of lurking and peripheral participation.

Viewing the theories of Behaviourism, Cognitivism, Constructivism, and Connectivism as providing a continuum of learning strategies gives insight into the needs of learners, and also into the development of learning materials and learning activities. As these theories and associated methods overlap and complement each other, the design of a new learning environment must incorporate methods that will enable a balance of strategies for learning to occur throughout this continuum.

Interaction in learning environments has been defined as occurring between, learners and content, learners and learners, learners and teachers or instructors, teachers and teachers, plus teachers and content. Each of these interactions has been described as essential for learners to create meaning and understanding. The dialogue between learners, content and teachers all contribute to the learning experience. A web-based 3D virtual learning environment must be designed to maximise these interactions for optimal learning to take place.

This research project was conducted in a polytechnic with a very wide range of learners with a range of needs as learners. A useful framework for this consideration was the pedagogy, andragogy, heutagogy continuum that provided guidance on the design of learning activities and provided a focus to create an effective design for the 3D web-based virtual learning environment.

The influence of these theories on the selection of software is discussed in Chapter Five. The influence on the designs created for the web-based 3D virtual learning environments is discussed in Chapter Seven, along with technology limitations restricting the usefulness or inclusion of some features.

## **CHAPTER 3**

### **LEARNING ENVIRONMENT RESEARCH**

Instructing is done to help people learn. It can be done well or badly. Sometimes it is difficult to tell which of these ways has been chosen. (Gagne, 1974, p. 3)

#### **3.1 INTRODUCTION**

This chapter introduces the survey instrument used for the quantitative aspect of this research. The long history and proven record of the selected survey approach is discussed and the selection and customisation of a specific instrument is detailed.

To facilitate the development of successful learning environments, it is important to gain an understanding of how well the environments are working for the learners and teachers using them and how well they are supporting the learning process. To develop this understanding, a reliable evaluation method is required. The virtual learning environments utility, for both learners and teachers, must be studied to develop an understanding of the effectiveness of these environments and guide future development. Learning environment research has established that there is a strong correlation between student outcomes and the students' perception of the learning environment, and that the learning environment has a significant impact on student learning outcomes (Fraser, 1994, 1998b).

Since the late 1960s, the field of learning environment research has generated a rich collection of instruments that are proven to provide an accurate picture of the effectiveness of the learning environments investigated. Learning environment research has now moved into the area of evaluation of virtual learning environments. Evaluation instruments have been designed and proven for web-supported and web-based learning environments (Chang & Fisher, 2003). These instruments are being used to give valuable feedback to the designers of web-supported and web-based distance learning environments.

### **3.2 LEARNING ENVIRONMENT RESEARCH**

The concept of learning environment has existed since the 1930s (Goh & Fraser, 1998). Learning environment research refers “to the social, physical, psychological, and pedagogical contexts in which learning occurs and which affect student achievement and attitudes” (Fraser, 1998a, p. 3).

Learning environment research has been firmly established in the traditional or classroom environment particularly in the field of science education (McRobbie, Fisher, & Wong, 1998; Tobin, 1998). This research has generated a rich array of instruments that have been proven to provide an accurate picture of the effectiveness of the learning environments investigated. One of the greatest strengths of learning environment research lies in its international flavour through attracting an international group of scholars. Therefore, many of the concepts, operations, and theories have been examined in multiple countries and cultures, resulting in a rich field of enquiry (Johnson, 2002).

Originating from investigation into the psychological aspects of social environments, learning environment research has evolved to include many different instruments to evaluate different types of learning environments. These instruments measure the learners’ and/or the teachers’ perceptions of their specific learning environment. Recently, learning environment research has moved into distance and web-based learning environments, with new instruments developed for the purpose of evaluating and improving the participants’ perceptions of these environments.

Learning environment research has a firm theoretical basis using conceptual frameworks developed by Moos (1974b), Pace and Stern (1958), Gardiner (1989), Bloom (1956) and Krathwohl, Bloom and Masia (1964) to underpin the scales used in the instruments.

Students have a distinctive frame of reference generated from spending numerous hours as learners, they have an immense interest in what is going on around them in their educational environments “their reactions to and perceptions of school experiences are significant” (Fraser, 1998c, p. 527). Furthermore, students have the advantage of familiarity with differing learning environments and have distinctive impressions of classroom environments (Moos, 1979). Therefore, a large

proportion of learning environment research is based on students' perceptions of their learning environment.

The theoretical framework developed by Moos centred on the universal environmental dimensions of relationship, personal relevance, and system maintenance and change, and has led to a solid theoretical structure for research investigating learning environments. This was further developed when Gardiner identified additional dimensions in the environment as containing ecosphere, socioshere and technosphere (Gardiner, 1989).

Bloom, Engelhart, Furst, Hill and Krathwohl, identified three domains of behaviour: cognitive, affective, and psychomotor. The cognitive domain is defined as consisting of six major categories of thinking: knowledge, comprehension, application, analysis, synthesis, and evaluation. These categories are roughly hierarchical. Knowledge is considered a low-level cognitive ability and evaluation a high-level cognitive ability. This contributes scales related to the prevalence of activities in the affective and cognitive domains of the classroom (Bloom, et al., 1956).

The work of Moos, Gardener, and Bloom et al. is discussed in more detail in the following sections.

### **3.3 UNDERLYING CONCEPTS**

The concepts underlying learning environment research have their roots in psychosocial research that investigates the relationship between people's perceptions of their environment and their behaviour.

Research in the 1930s investigated the relationship between the environment and a persons' behaviour. Lewin's basic idea was that the individual person is more shaped by their social environment (groups) than by their genes, he drew on the field of Gestalt Psychology. In 1936 Lewin stated behaviour is a function of personality and environment, expressed as the function  $B = f(P, E)$  where human behaviour (B) as a function of two interdependent influences, the Person (P) and the Environment (E) (Hall & Lindzey, 1978). Additionally, the work of Hartshorne & May (1928) demonstrated that children will behave differently depending on the situation

(Hartshorne & May, 1928), plus the work of Newcombe (1929), who demonstrated that children's talkativeness in the lunch environment was a very stable trait but that this did not carry over to other situations (Moos, 1979).

Murray (1938) developed Lewin's theory to describe the concept; of the personal needs of an individual, including goals and drives; and the environmental press, including stimulus, treatment, and process variables. Murray suggested a Needs-Press Model of interaction between personal needs and the environmental press where they live. In this model, personal needs refer to the tendency for individuals to move in the direction of goals; on the other hand, the environmental press refers to the external situation that either supported or hindered the realization of personal needs. Murray insisted that individuals would avoid situations perceived as harmful whereas they would try to access environments perceived as beneficial.

These early investigations demonstrated that researchers must consider the environment in which behaviour takes place in order to predict individual student actions, as these actions change in accordance with the nature of the setting (Moos, 1976).

Moos (1974a) investigated the effect of students' environments on their ability to reach their potential and identified a scheme for classifying human environments. This scheme identified three types of dimensions in the human environment. The first was the Relationship dimension, which identifies the nature and strength of personal relationships in an environment. The second was the Personal Development dimension, which involves the basic directions along which self-enhancement and personal growth appear. The third was the System Maintenance and System Change dimension which involves orderliness of the environment, clarity of expectations, control, and responsiveness to change (Fraser, 1998b; Moos, 1974b). This scheme has been used to develop instruments that measure the perceptions of the participants in a learning environment for one or more of these dimensions using specific scales.

The Relationship dimension distinguishes the extent of peoples involvement in the environment and this is the extent to which people work with one another and support and assist one another. Scales in learning environment research that are

related to this dimension include: Cohesiveness, Expressiveness, Support, Involvement, Affiliation, and Involvement.

Scales in learning environment research that are related to the Personal Development dimension include: Independence, Task Orientation, Self-Discovery, Anger, Aggression, Competition, Autonomy, and Personal Status.

The System Maintenance and System Change dimension considers the degree of control of the environment. Scales in learning environment research that are related to this dimension include: Organization, Control, Order, Clarity, Innovation, Physical Comfort, and Influence (Moos, 1976).

### **3.4 OTHER SCALES: BLOOM'S TAXONOMY**

In the late 1950s, Bloom developed a Taxonomy of Educational Objectives as a tool to assist evaluators to classify test items and testing outcomes (Bloom, et al., 1956). This taxonomy specifies three domains of behaviour: Cognitive, Affective, and Psychomotor. Bloom believed that the majority of educational outcomes come from the cognitive behaviour domain which represents the use of knowledge or intellectual ability. Bloom et al. identified six major categories of thinking in the Cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. These categories are roughly hierarchical. Knowledge, comprehension, and application are considered low-level cognitive abilities. Learners typically rely upon inert knowledge, such as a single memory, interpretation, or rule to evoke these types of responses. For example, to be able to creatively put together several basic concepts to create a new idea, a learner must have a good understanding or comprehension of the basic concepts. Analysis, synthesis, and evaluation are high-level cognitive abilities. Questions framed by one of these classifications require the learner to invoke multiple memories, interpretations, and rules. Furthermore, learners have to place these thoughts into a new contextual environment. Therefore, these cognitive abilities require knowledge that is dynamic. Although Bloom's taxonomy is not the only possible way to classify thinking levels, it is widely known and used in education, and therefore provided a useful framework to evaluate the learning environment.

During the 1990s, a former student of Bloom's, Anderson, led an initiative to update this taxonomy, hoping to create a revised taxonomy that would be more relevant to students and teachers in the 21st century. This time “representatives of three groups [were present]: cognitive psychologists, curriculum theorists and instructional researchers, and testing and assessment specialists” (Anderson & Krathwohl, 2001). Published in 2001 this revision contains significant changes. With the changes in society since the original taxonomy was proposed, the Revised Bloom's Taxonomy provides an even more powerful tool to fit the current needs of educators. The Revised Taxonomy Table matrix “provides a clear, concise visual representation” (Krathwohl, 2002) between educational goals and products or activities.

Table 3.1  
*The Revised Bloom's Taxonomy Table Matrix*

The Knowledge Dimension	The Cognitive Processes Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	List	Summarize	Classify	Order	Rank	Combine
Conceptual Knowledge	Describe	Interpret	Experiment	Explain	Assess	Plan
Procedural Knowledge	Tabulate	Predict	Calculate	Differentiate	Conclude	Compose
Meta-Cognitive Knowledge	Appropriate Use	Execute	Construct	Achieve	Action	Actualize

Bloom's Affective domain was defined by Bloom et al. (1964). The Affective domain relates to emotions, attitudes, appreciations, and values, such as enjoying, conserving, respecting, and supporting. It consists of behaviours corresponding to: attitudes of awareness, interest, attention, concern, and responsibility, ability to listen and respond in interactions with others, and ability to demonstrate those attitudinal characteristics or values which are appropriate to the test situation and the field of study (Krathwohl, et al., 1964).

Scales in learning environment research that are related to Bloom's taxonomy includes scales that are designed to measure the prevalence of activities in the affective and cognitive domains of the classroom (Anderson & Walberg, 1974).

### **3.5 EXPANSION OF THE ENVIRONMENTAL DIMENSIONS**

Gardner (1989) identified additional dimensions related to the environmental dimension; these are the dimensions of Ecosphere, Sociosphere, and Technosphere. This initiated the developments of new instruments designed to measure environmental variables associated with the ecosphere, such as the resources available, and the technosphere, such as technical infrastructure (Gardiner, 1989).

Gardiner (1989) describes a general framework for thinking about the pressures that may be driving change in human environments. Gardiner's model consists of three overlapping spheres of influence that he describes as the ecosphere, the Sociosphere, and the Technosphere. The Ecosphere relates to a person's physical environment and surroundings, whereas the Sociosphere relates to an individual's interactions with all other people within that environment. Finally, the Technosphere is described as the total of all the person-made things in the environment.

Gardiner described the individual person located in the centre of the model as the most complicated component in the system. Located at the intersection of these three spheres, people are subjected to all three influences. Learning environment studies in technological settings were further developed to utilize this conceptual model of competing environmental influences to increase understanding of the learning environment. This led to the scales related to the physical and the psychosocial learning environment, particularly when the classroom incorporated the use of new information and communications technology (Zandvliet, 1999).

### **3.6 ACTUAL AND PREFERRED FORMS**

The work of Murray (1938) was used as a foundation for the development of comparative forms of learning environment research, where preferred learning environments were compared with actual environments. Murray used the concept "alpha press" to describe the environment as characterized by an outside, detached observer, and the concept "beta press" to describe the consensual, perceived environment of the participants themselves. He developed the term "press" to reflect a directional tendency in a situation or object that either facilitated or impeded an individual's efforts to attain a particular goal (Ó Fathaigh, 1997).

Pace and Stern applied the rationale of “perceived climate” to the study of the “atmosphere of colleges and universities”, effectively operationalising Murrays concept of “environmental press” (1958, p. 269). In 1970, Stern developed a theory relating the degree of person–environment congruence to student outcomes, based on the needs press theory of Murray (1938). This has been used as the basis for learning environment studies that measure the congruence between the preferred environment and the perceptions of the actual environment, and relate these to student outcomes (Fraser & Fisher, 1994).

Learning environment research has been further developed to include instruments that correlate student perceptions of their preferred learning environment, with their perceptions of the actual learning environment. The practical implication for learning environment studies is, that attempting to change the actual classroom environment in ways that make it more congruent with that preferred by the students, could enhance student achievement (Fraser, 1994).

### **3.7 LEARNING ENVIRONMENT INSTRUMENTS**

The field of learning environment research is broad in terms of both substance and methods. A large number of scales have been developed and many of these are available for researchers to use without having to construct their own instruments and validate these instruments.

Early learning environment surveys and inventories that explored the broad picture of learning environment activities and relationships have been expanded. For example, constructivist views of learning, and the shift from teacher centred instruction to learner centred construction of knowledge, have influenced the development of a number of instruments (Taylor & Maor, 2000; Walker, 2003b). Instruments have been developed to investigate computer simulations (Maor, 1999a) and computer-supported learning environments (Newhouse, 2001). Through ongoing research in many different learning environments the instruments developed have been proved to be flexible (Ommundsen, 2001), reliable and cost effective (Fraser & Wubbels, 1995). This demonstrates the feasibility of developing learning environment instruments capable of successfully analysing the wide range of

learning environments created when using connected computers and the World Wide Web in teaching and learning.

To assist in understanding the complex array of instruments available it is useful to group them into categories. There are many different ways in which the instruments can be grouped. They can be grouped by the target group: tertiary, high school, middle school, primary, or kindergarten. They can be categorized by subject area: Physics, Geography, Science, Mathematics etc. They can be grouped by type of classroom: technology rich, computer laboratory, science laboratory, distance, online, or web- supported. They can be grouped according to the learning theories supported: behaviourist, constructivist, cognitive apprenticeship, or they can even be ordered by date. Initially, I have chosen to group them by the base instrument from which they have been derived. Inherently, this groups them by the theoretical context and taxonomies upon which they are based.

### **3.8 EARLY INSTITUTION-LEVEL INSTRUMENTS**

Walberg and Moos, independently began studying psychosocial environments and their influences on student outcomes in the late 1960s. Their work has been defined as the “starting points for contemporary classroom environment research” (Fraser, 1990, p. 201) that “took off in the 1970s” (Tobin, 2000, p. 223).

Earlier instruments were designed to study schools as organisations, however statistical evidence suggested that the relationship between school and classroom learning environments was weak and indirect, if not insignificant (Dorman, Fraser, & McRobbie, 1997), leading to a new focus for learning environment research, and contemporary instruments designed to focus on the individual classroom.

Moos (1974b) advocated the study of individual classrooms from the participants’ perspective as previous school level studies had shown relatively little overall differences between schools. He described the contemporary instrument, the *Classroom Environment Scale* (CES), as taking a different approach from the earlier surveys that focused on the school and classroom as an organization and drew from work in the field of business organizations. In addition, Moos described earlier classroom studies as focusing on coding schemes for classroom activities and teacher interactions; observation scales, and self-report, or perpetual indexes focusing on the

atmosphere in the classroom. These types of studies were conducted by observers who were involved in the individual classroom environments for relatively short periods of time (Moos, 1979).

Examples of these earlier instruments include the *College Characteristics Index* (CCI) (Pace & Stern, 1958) and the *Organizational Climate Description Questionnaire* (OCDQ) (Halpin & Croft, 1963). The OCDQ used a personality metaphor to assess the school's degree of openness in interpersonal relationships. Openness was defined as the extent to which relationships are authentic, caring, and supportive and the extent that the behaviour of both teachers and principals was straightforward and open. A closed school personality was defined as manipulative, game playing, involving suspicion, and politicking (Young, 1998). The CCI was developed as an institution level instrument designed for use in Universities to measure the college "press", pressures being exerted by the schools, as perceived by students. The intent of the CCI was to "reveal a person-environment 'fit' which would influence academic performance and student satisfaction" (Baird, 1988, p. 4).

The *College and University Environment Scales* (CUES) (Pace, 1962, 1967) was developed from the earlier work of Pace and Stern. The CUES is also an institution level instrument and was designed to measure differences between institutions. It consists of five scales, Practicality, Community Awareness, Proprietary, and Scholarship.

A more recent school level instrument is the *School Level Environment Questionnaire* (SLEQ) (Rentoul & Fraser, 1983). This instrument was designed specifically to assess schoolteachers' perceptions of the psychosocial dimensions of the environment of the school. The SLEQ is a 56-item teacher survey that measures school climate along eight dimensions: Affiliation, Student Supportiveness, Professional Interest, Achievement Orientation, Formalization, Centralization, Innovativeness, and Resource Adequacy (Fisher & Fraser, 1990).

### **3.9 CONTEMPORARY CLASSROOM LEVEL INSTRUMENTS**

As learning environment research progressed there was evidence that learning outcomes and student attitudes towards learning were closely linked to the classroom environment. Research was then conducted to determine the degree of importance of

the classroom environment in the teaching-learning process. During this process of studying classroom environments, various forms of measurements were developed to measure the psychosocial environment in different school contexts. Among the well used instruments for studying classroom environments in secondary schools were the *Learning Environment Inventory* (LEI) (Fraser, et al., 1982), the *Classroom Environment Scale* (CES) (Moos & Trickett, 1986), the *Individualised Classroom Environment Questionnaire* (ICEQ) (Fraser, 1987), and the *What is Happening in this Class* (WIHIC) (Fraser, Fisher, & McRobbie, 1996).

### **3.10 LEI BASED INSTRUMENTS**

The *Learning Environment Inventory* (LEI) was developed and validated in the late 1960s. It is based on the premise students, as well as the teacher, are determinants of the learning environment (Anderson & Walberg, 1974). The LEI is designed to measure the student's perceptions of the learning environment through 35 scales, each consisting of seven questions. These scales are designed to measure the three types of environment dimensions identified by Moos: the scales on Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction and Apathy are related to the Relationship dimension; the scales on Speed, Difficulty and Competitiveness are related to the Personal Development dimension; and the scales on Diversity, Formality, Material Environment, Goal Direction, Disorganisation and Democracy are related to the System Maintenance and Change dimensions (Fraser, 1998b).

The LEI was originally developed for use with high school students studying physics in Australia. Initially there was evolutionary change to these scales as the scales were refined to make them easier to administer or altered to tailor the instruments to a particular age group, subject area, or culture, leading to a large number of studies and new instruments with small variations.

The *My Class Inventory* (MCI) (1981) was a redesign of the LEI to enable the instrument to be used with younger children. It is a simplified version of the LEI, adapted for younger children aged 6-12 years (Fisher & Fraser, 1981). The major changes included reducing the number of scales from 15 to 5 to reduce the amount of time required to answer the questionnaire, rewording of questions to simplify the

questions for the younger students, change from a four point Likert scale to a yes no answer format and inclusion of the answer space on the question sheet.

The *College and University Learning Environment Inventory* CUCEI (1986) was developed to assess the learning environment at the higher education level, (Fraser & Treagust, 1986). It was initially developed for use with small groups of about 30 students in seminars and tutorials in higher education classrooms (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986). In 1987, the CUCEI was refined to be a more general instrument to assess perceptions of the psychosocial environment in university and college classrooms (Fraser, Treagust, Williamson, & Tobin, 1987). It was designed to fill a gap identified in the availability of instruments suitable to assess the psychosocial learning environments at tertiary level (Fraser, et al., 1986; Ramsden, 1991; Ramsden, Martin, & Bowden, 1987; Ramsden, Patrick, & Martin, 1988; Richter, 1997). The final form of the CUCEI contains seven scales: Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualization. Each scale comprises seven items, making a total of 49 items in all (Khine & Goh, 2001).

The *Science Laboratory Learning Environment Inventory* (SLEI) (Fraser, Giddings, & McRobbie, 1995) was designed for use with upper secondary and tertiary students. The SLEI has five scales of seven items and was tested and validated with over 5,447 students in six countries (Fraser & McRobbie, 1995).

The *Computer Classroom Environment Inventory* (CCEI) (Maor & Fraser, 1996) was designed to assess physical and psychosocial aspects of the learning environment in information technology rich classrooms. The CCEI employed a hierarchical rating scale, scored out of five, which gave an estimate of a classroom's degree of "fit" with currently published ergonomic guidelines (Kroemer & Etienne, 1997). The inventory includes five scales: Investigation, Open-endedness, Organization, Material Environment and Satisfaction.

The *Computer Laboratory Environment Inventory* (CLEI) (Newby & Fisher, 1997) is a refined version of the SLEI designed for use with upper secondary and tertiary students, and the *Environmental Science Learning Environment Inventory*

(ESLEI) (Henderson, Fisher, & Fraser, 1998) was designed for use with secondary science classes.

### **3.11 CES BASED INSTRUMENTS**

The *Classroom Environment Scale* (CES) (Trickett & Moos, 1974) was designed to consider teacher behaviour, teacher-student interaction and student-student interaction (Moos, 1979). The introduction of the CES, was described as a major change from the then prevalent perceptual indices that “lacked the guidance of theoretical or conceptual frameworks producing isolated findings that are difficult to organize into a coherent body of knowledge about classroom functioning” (Moos, 1979, p. 138). The CES, and the numerous instruments that follow, defined the classroom environment in terms of the shared perceptions of the participants, rather than the perceptions of outside observers.

The *Adult Classroom Environment Scale ACES* 1996 contains seven dimensions that examined the following: Affiliation, which is the extent students like and interact positively with each other; Teacher Support, which is the extent of the help, encouragement, concern and friendship the teacher directs towards students; Task Orientation, which is the extent to which students and teacher maintain focus on the task and value achievement; Personal Goal Attainment, which is the extent to which the teacher is flexible, providing opportunities for students to pursue their individual interests; organization; Clarity, which is the extent to which the class activities are clear and well organised; Student Influence, which is the extent to which the teacher is learner-centred and allows students to participate in course planning decisions; and Involvement, which is the extent that the students are satisfied with the class and the extent that they participate actively and attentively in activities (Darkenwald, 1987; Ó Fathaigh, 1997).

The *Constructivist Learning Environment Survey* (CLES) (Taylor, Dawson, & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser, & White, 1994) was developed to assist educators and researchers to measure students’ perceptions of the extent to which constructivist approaches are presented in the secondary school classrooms’ learning environment (Taylor, Fraser, & Fisher, 1997). The first version of the CLES was introduced in 1991 (Taylor & Fraser, 1991) and was consistent with

von Glasersfeld's (1981, 1988) perspective of radical constructivism. This version of the CLES was designed to measure students' perceptions of the extent to which the classroom-learning environment enabled them to reflect on their prior knowledge, develop as autonomous learners, and negotiate their understandings with other students. Socio-cultural aspects were added to the instrument in the development of the revised versions.

The *Constructivist Learning Environment Survey* (CLES) was later revised creating new versions of the CLES. These were developed based on its original version and the perspective of critical constructivism (Taylor & Campbell-Williams, 1993). These versions of the CLES were designed to measure five key dimensions of a critical constructivist learning environment from the students' perception. The five key elements emphasised are: the degree of relevance the students find between their studies and the world outside of school; the degree of empowerment they gain to express their concern about the teaching and learning; the degree to which they are invited to share control of the design, management, and evaluation of their learning; the degree of their engagement and interaction with each other to improve their understanding; and the extent to which science is viewed as ever changing (Taylor et al., 1995; Taylor et al, 1997).

The revised versions of the CLES are available in two forms: the actual and the preferred (Taylor et al., 1995). In addition to the actual form that measures the learning environment as perceived by students, the preferred form is concerned with goals and value orientations and measures perceptions of the classroom environment ideally liked or preferred (Fraser, 1998b). Learning environment research that has adopted a person-environment fit perspective (Hunt, 1975) has revealed that the similarity between the actual environment and that preferred by students leads to improved student achievement and attitude (Fisher & Fraser, 1983; Fraser & Fisher, 1983a, 1983b). Each form contains 30 items altogether, with six items in each of the five scales. The scales of the CLES are: personal relevance, uncertainty, critical voice, shared control, and student negotiation (Taylor et al., 1997). This version of the CLES was used in studies of high school science and mathematics classrooms (Dryden & Fraser, 1998; Taylor, et al., 1995; Taylor, et al., 1994) and validated in studies in different countries. The CLES has also been translated and modified to

suit many specific situations for use in both English and non-English speaking countries (Churach & Fisher, 1999; Stolarchuk & Fisher, 2001).

The *Constructivist Multimedia Learning Environment Survey* (CMLES) was developed to exclusively consider constructivist oriented learning environments that made use of interactive multi-media in teacher professional development (Maor, 1999b).

The *Constructivist On-Line Learning Environment Survey* (COLLES) was developed from its three-scale predecessor, the Constructivist Virtual Learning Environment Survey (CVLES) (Taylor & Maor, 1998), to measure questions about the quality of online learning environments from a social constructivist perspective in an effort to ensure that “technological determinism doesn’t overshadow sound educational judgment” (Taylor & Maor, 2000). The COLLES is arranged in six scales of: Relevance, Reflection, Interactivity, Tutor Support, Peer Support, and Interpretation.

### **3.12 INQUIRY BASED APPROACHES TO LEARNING**

The *Individualized Classroom Environment Questionnaire* (Fraser, 1985) was developed to measure the factors which differentiate conventional classrooms from those with either open or inquiry-based approaches, and Fraser (1986) supplies a list of studies using the ICEQ, which suggests that promotion of classroom environment characteristics such as cohesiveness, goal direction and democracy has consistently positive influences on learning outcomes. In addition, Fraser states that teachers can expect students to achieve better when there is a greater similarity between actual and preferred classroom environments (Fraser, 1986, p. 137). The initial version of the ICEQ long form had five scales with approximately 15 items per scale. The final published version of the ICEQ (Fraser, 1990) contained 50 items evenly distributed across the five scales, of Personalisation, Participation, Independence, Investigation, and Differentiation. A short form of the ICEQ was also constructed (Fraser, 1990). The short form retained all five scales of the long form, but contained only five items in each of the scales. Both actual and preferred versions of the short form of the questionnaire are available.

The *What Is Happening in this Classroom?* (WIHIC) instrument focuses on secondary classrooms, combining modified versions of the most relevant scales from a range of existing questionnaires plus additional scales that accommodate current concerns such as constructivism and equity (Aldridge, Fraser, & Huang, 1999; Fraser, et al., 1996). The WIHIC was trialled as a 90 item, nine-scale version with 355 junior high school students. This was refined following extensive interviewing of students about their classroom environments and the wording of the questionnaire (Fraser, et al., 1996). This led to a final form containing seven eight-item scales. It has been shown to have high reliability and validity in educational settings. It has been translated into several other languages and cross validated. Zandvliet and Fraser (2004) used the WIHIC with 81 senior high school students in Canadian and Australian internet classes, Lightburn and Fraser (2002) and Robinson and Fraser (2003) used WIHIC in teacher-researcher studies in Florida. Dorman and Adams (2004) used the WIHIC with 3980 students assessing the learning environments of math classes in secondary schools in Australia and Britain. The WIHIC has been translated into Chinese, Indonesian and the Korean languages. The WIHIC has also formed the foundation for the development of new learning environments questionnaires, that incorporate many of its existing dimensions while adding new dimensions relevant to specific studies (Fraser, 2007).

The *Technology-Rich Outcomes-Focused Learning Environment Inventory* (TROFLEI) (Fisher, Aldridge, Fraser, & Wood, 2001) was developed from the WIHIC and was initially consisted of 24 items in three scales drawn from multiple widely used classroom instruments plus some additional new scales. The TROFLEI has since been revised and now contains 76 items in 10 scales (Aldridge, Fraser, Fisher, Trinidad, & Wood, 2003). Aldridge et al. (2003) used the TROFLEI to measure students' attitudes toward their subject matter, attitudes toward computer usage, academic efficacy, and student achievement in conjunction with their perceptions of the psychosocial environment using scales for gender equity, investigation, innovation, and resource adequacy.

### 3.13 ONLINE LEARNING INSTRUMENTS

Since 1995 several instruments have been developed for use in online learning environments: The *Distance and Open Learning Environment Scale* (DOLES), the *Web-based Learning Environment Instrument* (WEBLEI), the *Distance Education Learning Environments Survey* (DELES) and the *On-line Learning Environment Survey* OLLES.

The DOLES (Jegede, Fraser, & Fisher, 1995) brought learning environments research and distance education research together into one study. It was developed for web-delivered science courses. Like early distance education research, it had aspects focusing on technology and interaction, measuring student perceptions of their learning experience related to the eight components of effective learning environments: interactivity, institutional support, task orientation, teacher support, negotiation, flexibility, technological support, and ergonomics (Jegede, et al., 1995). The scales of the DOLES are: Student Cohesiveness, Teacher Support, Personal Involvement, plus two optional scales: Student Centred Environment and Technology Resources. The DOLES is a paper-based instrument initially validated on 660 responses to five core scales from distance education science classes from Queensland and Western Australian universities. The optional scales were validated on 169 responses (Jegede, Fraser, & Fisher, 1998).

The DELES was developed in 2003 and is designed to examine distance education environments for tertiary education. There are seven scales that cover: Instructor Support, Student Interaction and Collaboration, Personal Relevance, Authentic Learning, Active Learning, and Student Autonomy and Satisfaction (Walker, 2003a).

The Online Learning Environment Survey (OLLES) was developed in New Zealand in 2003 – 2004 and is designed for tertiary education. The OLLES contains eight scales Reflective Thinking, Information Design and Appeal, Order and Organization, Active Learning, Affective Support, Student Cohesiveness and Affiliation, Computer Anxiety and Competence, Material Environment and Rule Clarity. These scales are nearly equally stratified across Moos' three social organization dimensions (Clayton, 2005).

The WEBLEI was developed in 2001 for university web-based and web-supported learning environments (Chang & Fisher, 2001a). The WEBLEI draws on the long history of research instruments derived from the LEI, addressing learning effectiveness in terms of a cycle that includes access to materials, interaction, students' perceptions of the environment, and students' determinations of what they have learned (Chang & Fisher, 2001b). These factors are summarized in four scales: Access which covers emancipatory activities, such as convenience, efficiency, and autonomy; Interaction which covers co-participatory activities, such as flexibility, reflection, quality, interaction, feedback, and collaboration; Response which covers enjoyment, confidence, accomplishment, success, frustration, and tedium; and Results which covers information structure and design activities, such as organization, relevance, accuracy, and balance of learning materials (Chang & Fisher, 2003). The WEBLEI was trialled to test the instrument's validity and reliability. Initially it was validated from responses of 334 postsecondary students enrolled in a subject that could be taken either in blended mode (partially online, partially face-to-face) or taken 100% online. Just over 73% of the responses were from students taking the class fully online (Chang & Fisher, 2001b). The pilot study confirmed that there were indeed four scales in the WEBLEI. The Cronbach alpha reliability coefficients ranged from 0.65 to 0.88. The discriminant validity showed that the mean correlations ranged from 0.38 to 0.52 indicating that the four scales of the WEBLEI measure distinct and somewhat overlapping aspects of the on-line learning environment (Chang & Fisher, 2001).

### **3.14 USE OF WEBLEI FOR THIS STUDY**

The WEBLEI was selected as a suitable instrument to study online learning environments, including the study of web-based 3D virtual worlds being used for online learning, as it is targeted for web-based learning environments and web-supported learning environments. Furthermore, it is designed for a tertiary environment measuring web-based learning effectiveness in terms of a cycle that includes access to materials, interaction, students' perceptions of the environment, and students' determinations of what they have learned (Chang & Fisher, 2001b). Minor changes have been made to the wording of the survey after trials with local students highlighted a few areas of confusion, and several of the questions that

named specific communication technologies such as email were altered to reflect the broader range of communication technologies available in the 3D virtual learning environment (see section 4.4.1 for details of these changes).

### **3.15 SUMMARY**

This chapter has summarized the development of a series of learning environment survey instruments, detailing the long history, and proven record of this area of research.

The WEBLEI was selected as a suitable instrument to study students' perceptions of 3D virtual worlds in online learning. The WEBLEI was used as part of the data collection for the evaluation of this research project; the results were used to inform the development of the successive iterations of the 3D virtual learning environment. The results from this survey instrument are presented in Chapter Six, and the analysis of the survey data is integrated and synthesized with other data collected during this research in the discussion in Chapters Eight and Nine.

## **CHAPTER 4**

### **RESEARCH METHODOLOGY**

Challenge what is, incite what could be, and help imagine a world that is not yet imagined (Fine, 1994, p. 30)

#### **4.1 INTRODUCTION**

This chapter addresses the methodologies selected for this research. It covers the research perspective, the reasons the research methods were chosen, the design of the study, the design of the instruments used, and the methods of evaluation. It discusses the processes followed to build and evaluate an online virtual classroom created using a 3D environment building tool.

This research was oriented towards revolutionary change rather than incrementally evaluating and improving an existing framework. The practice of teaching and learning using this environment was being developed as the research progressed. This meant that the research needed to both explore the research questions and explain the phenomena observed.

The research was based on a pragmatist view of research and the inquiry strategy followed a mixed method approach concurrently collecting both quantitative data and qualitative data over several research cycles. The methods of data collection and data analysis combined elements of quantitative study with qualitative study integrating the information in the interpretation of the results. The research methodology was based on a participatory action research methodology, following a research by design process. The survey instrument design was based on the WEBLEI, itself arising from a long history of learning environment research instruments described in Chapter Three. The software was designed and built following principles of Human Computer Interaction and best practice for 3D world design. Evaluation methods followed both qualitative and quantitative methods in an approach that provided multiple sources of data and multiple perspectives.

## 4.2 RESEARCH QUESTIONS

The objective was to build a web-based 3D virtual learning environment for education with the aim of providing a compelling online learning environment. The research was based on the premise that communication both between student peers and between student and teacher is a fundamental part of learning. Therefore embedding multiple channels for communication in an online environment should facilitate this process. The focus was on developing an understanding of methods that could be used to facilitate the learning process in a web-based 3D virtual environment, and seek explanations for the current lack of progress with the implementation of this style of web-based learning environment.

The following questions were identified in section 1.4 at the outset of this research. The first of these questions and the principle focus of this thesis, was whether these 3D worlds were a learning environment that enabled learners to experience success.

A. Is the environment, engaging, compelling, motivating?

The next group of questions was to provide guidance and insight into the processes that need to be supported in this environment. Initially this was to inform the design process and subsequently, to evaluate whether the expected interactions occurred and whether they had the expected effects.

B. What are the interactions between students, teachers, and tutors that contribute to the learning process?

C. How do these interactions facilitate the process of passing on knowledge and learning?

D. How are these interactions facilitated in the web-based 3D virtual education environment?

The last group of questions was to explore the effect of an inbuilt feature of the environment, its inherent visibility of participants who were online. Everyone viewing a particular world was represented as an avatar so it was not possible to be viewing a world and remain invisible. The questions were to investigate the impact of this on the “invisible student” phenomenon often referred to as lurking.

- E. How do people build up the trust to talk to fellow students, to ask questions?
- F. Is lurking (observing without interacting directly with other participants) a common phenomenon?
- G. If lurking is common what makes a difference to the lurking phenomena?
- H. If lurking is common, does participation by lurking affect people's perspective of the environment?

The answer to question A is fundamental to this research. The answers to the questions B through D are focused on the suitability of the created 3D environments for learning. The final questions, E through H are focussed on the students' methods of participating in the learning environment. The answers to the questions are provided in Chapter Nine.

### **4.3 RESEARCH METHODOLOGY**

Cresswell (2008) stated that a research methodology is based on a paradigm or world view, a strategy for inquiry, and research methods, and that these elements together provide a framework for a research study to be conducted.

#### **4.3.1 Research Paradigm**

This research is based on a pragmatic world view; which is a view that arises out of actions, situations, and consequences. There is a concern with what works and solution to problems (Patton, 1990). In this paradigm, researchers focus on the problem and use all approaches available to understand the problem. This philosophy focuses the researcher on the problem, using pluralistic approaches to derive knowledge about the problem.

For the mixed methods researcher, pragmatism opens the door to multiple methods, different world views and different assumptions, as well as different forms of data collection and analysis. (Cresswell, 2008, p. 11)

This research paradigm is not based in a duality between, determinism and cognitivism nor between qualitative or quantitative research paradigms, it is focused on providing the best understanding of the research problem.

The pragmatic paradigm implies that the strategy for inquiry will be a mixed methods strategy that includes elements of both quantitative and qualitative data collection and analysis.

#### **4.3.2 Research Strategy**

In human and social sciences, understanding of learning problems is frequently sought through quantitative studies, which are a means of testing objective theory. Relationships between variables are measured with numbers and analysed with statistical procedures in order to determine whether the predictive generalizations of the theory hold true. Alternatively, understanding may be sought through qualitative studies which involve emerging questions and procedures. Data analysis inductively builds from particular to general themes and focuses on individual meaning and the importance of rendering the complexity of the situation. This occurs in a natural setting. The quantitative method is also known as traditional, experimental, positivist or empiricist (Cresswell, 2008). The qualitative methodology is also known as a constructivist approach, naturalistic inquiry (Lincoln & Guba, 1985), interpretive inquiry (Smith, 1983) or postpositive or postmodern inquiry (Quantz, 1992). A mixed method research combines or associates both forms mixing both approaches in a study, so that the overall strength of the study is greater than either method on its own (Cresswell, 2008).

There is a wide variety of research methods available to a researcher in studying learning and education including ethnography, grounded theory, case studies, phenomenological research, narrative research, survey research, and experimental research. Shulman described a range of these methods:

A variety of methods comprise educational research: historical, philosophical, case study, ethnographical field studies, experiments, quasi experiments, surveys. Each is demanding and rigorous and follows disciplined rules or procedures. Taken together these approaches build a methodological mosaic

that is the most exciting current field of applied social research – the study of education. (Shulman, 1997, p. 13)

While the use of a mixed methodological approach is clearly challenging, this strategy is gradually gaining momentum in education (e.g., Blumenfeld & Meece, 1988; Fraser, 1991; Gogolin & Swartz, 1992; Shulman, 1997) and science education research (White & Gunstone, 1992). The mixed method approach can be further categorised as sequential, concurrent, or transformative. This research project followed a concurrent strategy through multiple iterations. Research using concurrent mixed method procedures involves the researcher converging or merging the quantitative and qualitative data to analyse the research problem integrating the information in the interpretation of the overall results (Cresswell, 2008).

#### **4.3.3 Research Methods**

The research methods used in the project are concerned with data collection, analysis, and interpretation. The research utilised a bricolage of research techniques drawn from quantitative and qualitative approaches following a mixed method inquiry paradigm. The concept of bricoleur is based on the French word for tinkering and is a common metaphor for the multiple methodologies of qualitative research. A qualitative researcher is viewed as a bricoleur or a professional handy person who uses the tools of his or her methodological trade and whatever strategies are at hand to understand the phenomenon in question (Denzin & Lincoln, 2005). This research has utilised a bricolage of research techniques drawn from quantitative and qualitative research techniques following a mixed method inquiry paradigm. The research utilised both data collection with predetermined characteristics as well as emerging methods, with both closed- and open-ended questions. There were multiple forms of data, statistical plus text, and image analysis using rich data and statistical databases.

#### **4.3.4 Research Cycles**

In this situation, an action research cyclic approach is very appropriate. The research involved multiple iterations of the research cycle refining the environment and data collection for each cycle. Action research has been defined as a deliberate,

solution-oriented investigation, characterised by a spiral of cycles consisting of problem identification, systematic data collection, reflection and analysis, data-driven action taken, followed by problem redefinition. An essential feature of this method is the linking of the terms “action” and “research” (Kemmis & McTaggart, 1988, p. 595).

Since its inception in the work of Lewin in (1946), the meaning and purpose of action research has taken on many forms. The different conceptions of action research can be revealed in some typical definitions, for example, as reported in Cohen, Manion and Morrison (2000), Hopkins (1985) and Ebbutt (1985) who suggested that the combination of action and research renders that action a form of disciplined inquiry, in which a personal attempt is made to understand, improve and reform practice. Cohen and Manion (1994, p. 186) defined it as “a small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention”. There are many other competing definitions of action research, they generally include collaboration, participation or social motivation. Most include reflection and some include repetition or incremental research cycles. These include:

Action research is a participatory, democratic process concerned with developing practical knowing in pursuit of human purposes, grounded in a participatory world view which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in pursuit of practical solutions to issues of pressing concern to people and more generally, the flourishing of individuals and their communities. (Reason & Bradbury, 2006, p. 1)

There are several terms in current use that describe research performed either by or in collaboration with practitioners and/or community members. The most common ones are action research; participatory action research; cooperative inquiry; educative research; appreciative research; emancipatory praxis; community-based participatory research; teacher research; participatory rural appraisal; feminist action research; feminist; antiracist participatory action research; and advocacy activist, or militant research. Each of these terms connotes different purposes, positionalities,

epistemologies, ideological commitments, and, in many cases, different research traditions that grew out of very different social contexts .... action research is the most generically used term in all disciplines and fields of study and it also makes action central to the research enterprise. (Herr & Anderson, 2005, p. 3)

Action research is the study of a social situation with a view to improving the quality of action within it. (Elliot, 1991, p. 69)

Action research is a form of collective self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of those practices and the situations in which the practices are carried out... The approach is only action research when it is collaborative, though it is important to realize that action research of the group is achieved through the critically examined action of individual group members. (Kemmis & McTaggart, 1988, pp. 5-6)

It is an approach to improve your own teaching practice. You start with a problem you encounter. Faced with the problem, the action researcher will go through a series of phases (reflect, plan, action, observe) called the Action Research Cycle to systematically tackle the problem. Usually you discover ways to improve your action plan in light of your experience and feedback from students. One cycle of planning, acting, observing and reflecting, therefore usually leads to another, in which you incorporate improvements suggested by the initial cycle. Projects often do not fit neatly into a cycle of planning, action, observation and reflection. It is perfectly legitimate to follow a somewhat disjointed process if circumstances dictate. (Kember & Kelly, 2010, p. 2)

Action research...aims to contribute both to the practical concerns of people in immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system concurrently with collaboration among members of the system in

changing it in what is together regarded as a desirable direction. (Gilmore, Krantz, & Ramirez, 1986, p. 161)

Action research is also given other names such as: participatory research, collaborative inquiry, action learning, and contextual action research. All are variations on the same theme. In essence, action research is a form of problem solving, a problem is identified to work on, with the aim to improve or solve it. The researcher gathers information on the problem and tries out new procedures or makes some other change in practices to see if they result in a solution. Often, a group identifies a problem, does something to resolve it, and assesses how successful their efforts were. If they are not satisfied, they try again. This form of research has a history that is rooted in problem solving in social and organizational settings.

The action research method has been further defined as having a number of subtypes: participatory research, critical action research, classroom action research, action learning, action science, soft systems approaches, industrial action research, and participatory action research (Kemmis & McTaggart, 2000b). As this research was concerned with creating a new learning environment, a participatory action research methodology was appropriate. Key features of participatory action research are described as:

...involving a spiral of self-reflective cycles of, planning a change, acting and observing the process and consequences of the change, reflecting on these processes and consequences and then, replanning, acting and observing, reflecting, and so on..." (Kemmis & McTaggart, 2000b, p. 595).

The process of analysis and reflection centred on the phenomena created through the design, build, trial and evaluation process, evaluating the outcomes, reflecting on reasons for the phenomena observed, planning and designing improvements then repeating the cycle. As each subsequent iteration of the environment was developed, the prototypes were extended to conduct investigations into observed phenomena and specific areas of enquiry.

An assumption of action research is that those who may otherwise be designated subjects should participate directly in the research process and that those

processes should be applied in ways that are of direct benefit to all participants (Glesne, 1999).

#### **4.3.5 Research Participants**

The research design included a participatory design methodology with the users of the environment, participating in its design and evaluation. The research investigated the design and use of the virtual learning environments to facilitate the communications interactions present in the teacher student matrix, focusing on the role of these interactions in the learning process. This followed an action research cycle through multiple iterations.

Participatory approaches also underlie the development methodologies associated with human computer interaction and are at the heart of participatory action research. One published study for the development and trialling of 3D virtual worlds is the Hutchworld study. This is a study of the development of a community support centre for cancer patients developed using a product, *Microsoft V-Chat*, which is similar to the software, *Adobe Atmosphere*, used in this research. This used a participatory approach and followed an iterative development methodology (Farnham, Cheng, Stone, Zaner-Godsey, & Clark, 2000; Farnham et al., 2002). This approach has been used successfully in both information technology projects (Bodker, et al., 1993) and community projects (Hasell, 1987).

The participative approach was pioneered and has been widely used in Europe since the 1970s. The focus of early participatory design proponents was to improve the quality of working life for those workers most at risk of unrewarding outcomes from information technology projects (Ehn, 1989). Participatory design has evolved as an approach that focuses on the intended users and involves them in development while relying on three main tenets (Blomberg & Henderson, 1990): focus on the quality of work life, rather than technological capability; be collaboratively and cooperatively oriented; and proceed iteratively, with interactive user evaluation. The focus now consists of a well-articulated and differentiated set of engineering methods in worldwide use (Greenbaum & Kyng, 1991; Muller, et al., 1997; Schuler & Namioka, 1993).

Gould and Lewis (1985) described three principles for user-centred design of instructional systems: an early focus on typical users and actual tasks; the use of empirical methods to assess the ability of the intended users to perform real tasks in the target context; and a focus on iterative, participatory design, incorporating the results of pilot testing, and feedback from typical users. This is very similar to the process described as participatory design.

Another advocate of participatory design suggests that typical end users should be in direct contact with the developers of an instructional system during the development process (Grudin, 1991). Some of Grudin's suggestions for narrowing the gap between designers and end users include: including end users in the design and development teams, designers participating in the local culture of the end users; integrating pilot testing, prototyping, and formative evaluation into the design process; and encouraging users to take more responsibility for their own environments. Another study found that close collaboration between the design team and typical end users led to a high degree of local adaptation and re-invention of on-line support for users (Sherry & Myers, 1998).

Furthermore, Kemmis and McTaggart (2000a) listed three attributes often used to distinguish participative research from conventional social research; shared ownership of research projects, community-based analysis of social problems, and an orientation toward community action.

Thus, participatory design involves the inclusion of users within the development process actively helping in planning prototypes and setting design objectives. It contrasts with other development methods that seek user input after the initial concepts, visions, and prototypes exist.

The development of systems for teaching and learning has been identified as an area where a long-term participatory approach is essential owing to the level of personal control and "invisible" nature of teachers' work plus the loose coupling to organizational workflow (Carroll, Chin, Rosson, & Neale, 2001). Participatory approaches also underlie the development methodologies associated with human computer interaction and are at the heart of action research.

#### **4.3.6 Research by Design**

The iterative nature of this research and the participatory design focus led to the research project following a design-based research approach focussing on each iteration and guiding the work on that iteration. Design-based research, sometimes named design research or design experiment, has become increasingly popular over the last decade. Brown (1992) and Collins (1992) introduced the term design experiments, however this has lost favour as the term experiment was often misleading. Collins provided the following example of a hypothetical design experiment questioning its validity as an experiment and proposing that it was design research not a design experiment:

Our first step would be to observe a number of teachers, and to choose two who are interested in trying out technology to teach students about the seasons, and who are comparably effective, but use different styles of teaching; for example, one might work with activity centers in the classroom and the other with the entire class at one time. Ideally, the teachers should have comparable populations of students ... Assuming both teachers teach a number of classes, we would help the teacher design her own unit on the seasons using these various technologies, one that is carefully crafted to fit with her normal teaching style (p. 19).

Collins' discussion explained that it was not an experiment because if differences in the outcomes from these contexts were found, it would be impossible to know to which variable these differences could be attributed and that it was not at all clear that this particular example could be described as an experiment in any sense. The term experiment has now changed to design research or design-based research, a change that removed some of the confusion associated with the name of the methodology.

The Design Based Research Collective, posits that design-based research will assist educators to narrow the chasm between research and practice. Part of the challenge is that research that is detached from practice "may not account for the influence of contexts, the emergent and complex nature of outcomes, and the

incompleteness of knowledge about which factors are relevant for prediction” (DBR Collective, 2003).

The techniques of design-based research have not been well established. Researchers have not yet fully articulated the ways that design and research goals intertwine with the goals of real-world practice in education. Some authors are beginning to describe how design-based research works on a day-to-day level in their specific work (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003).

While there is an ongoing debate about what constitutes design-based research (Van den Akker, Gravemeiger, McKenney, & Nieveen, 2006), the definition proposed by Wang and Hannafin (2005) captures its critical characteristics:

a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories (p. 6).

Joseph (2004) has listed three important characteristics of design-based research. First, design-based research creates opportunities for focusing on key questions, as in the case where a pilot study identifies a need for more intensive theorizing. Secondly, design-based research supports design progress with both formal research backing and rapid prototyping for example solving certain problems without attempting to understand them deeply. Thirdly, in design-based research, emergent theory shapes research methods as well as design. The conjoined goals of developing effective designs and contributing to basic understandings create, through their interactions, a powerful engine for driving innovative work in education (Joseph, 2004).

What marks design-based research as a unique enterprise is a commitment to understanding learning and instructional practice in authentic contexts and improving a program through iterative experimentation. Most design-based researchers want to study learning in rich contexts that can account for all the “messiness” that traditional laboratory studies seek to eliminate. As such, design-based research is a useful

framework for educators studying learning in existing classrooms and who have the ability to tweak or improve these environments toward building a better theory of learning or instruction (Barab & Squire, 2004).

As each iteration of the course was run there was a continuous improvement process used to make small changes in response to student requests or issues identified through monitoring the logs and observation of the usage. Between courses, major redesigns were carried out based on reflection and analysis of the preceding courses' delivery. The goal was to increase quality and effectiveness for the next course as understandings were generated from analysing the data.

After each iteration of the research, data gathered while the course was running were analysed and the progress made from the iteration was considered. A process of reflection and analysis was used to determine the directions and major changes required for each new iteration of the research.

#### **4.4 EVALUATION TECHNIQUES – DATA SOURCES AND DATA COLLECTION**

This research involved human participants; it was conducted as a student of Curtin University and as a tutor at the polytechnic. Applications were made to the Ethics Committees at both institutions detailing the purpose and nature of the research. Approval was gained prior to the participation of any students or polytechnic staff members. Consent was sought from all participants, and they were guaranteed that their contributions would be anonymous (see Appendix B). At all times the safety of the participating students was given the highest priority and assurance was made that under no circumstances could they be disadvantaged by either participation or non-participation in the research. Analyses of the data collected during each course were conducted after the course was completed. Interviews were only conducted with students once they had graduated from the programme (Chard, 2004a).

The iterative redevelopment of the environment has been based on reflective evaluation of the each cycle and followed a process that involved evaluators and stakeholders in a hermeneutic dialectic relationship. This relationship necessitated the open collection and interpretation of the data and involved discussion with all the

stakeholders (Guba & Lincoln, 1989). The research method used was largely contextual and thus difficult to replicate as a method of establishing reliability (Chard, 2004b).

Triangulation techniques have been used to enhance the rigour of the study (Mathison, 1988). These techniques have been applied throughout the research project at data source, data collection and data analysis levels (Patton, 1990).

Data have been collected from different stakeholder groups, including students, teachers, and support staff. The data have been collected through surveys, logs of activity kept by the software, artefacts from the activities, notes, and interviews that have been conducted with the participating students.

#### **4.4.1 WEBLEI**

The quantitative tool used for this research project investigated the perceptions of the students using the web-based 3D virtual environment and compared them to the perceptions of a control group of students using a web-based learning environment that did not include the 3D components. The WEBLEI was based on previous research instruments for the teaching/learning situation in a classroom, these instruments were adapted for the web-based learning environment, resulting in the development of the WEBLEI. Further minor changes were identified to adapt the WEBLEI to the 3D virtual learning environment. As discussed in Chapter Three, this evaluation method focuses mainly on the learning environment of the classroom and the inter-relationships that occur within it (Fraser, Treagust, et al., 1987; Fraser, Walberg, Welch, & Hattie, 1987; Moos, 1974a; Walberg, 1986). The analysis of the instruments available to measure student perceptions of their learning environments presented in Chapter Three, found that of the instruments available to measure classroom climate there are few that have been developed for tertiary education and the virtual classroom. The learning environment instruments that have been developed are used to measure the perceptions of students and teachers accumulated over many lessons (Fraser & Fisher, 1994). The instruments that have been developed to assess computer-based tertiary learning environments include the Computer Laboratory Environment Instrument and the Attitude towards Computers and Computer Courses Questionnaire (Newby & Fisher, 1997) plus the

WEBLEI (Chang & Fisher, 2003). The WEBLEI is targeted at online learning environments and is designed for a tertiary environment. This instrument was used in this research to provide an analysis of the student perceptions of virtual classroom.

An additional group of questions was added to gather demographic information about gender and age group at the start of the instrument. These were added to enable investigation of correlations to generational influences, or gender.

As stated previously, minor changes were made to the wording of the survey after trials with local students. These changes included: changing the wording for references to the lecturer or teacher to “tutor” to match the terms in common usage in the Polytechnic; splitting the questions about communication into several questions for each different electronic channel. For example, “I communicate with other students in my classes electronically using chat”. A clarification was added to explain what synchronous and asynchronous referred to “\* Synchronously: happening at the same time, \*\* Asynchronously: happening at different times”.

This research was undertaken in a blended delivery environment. This meant that it was possible for students to participate in the courses using only the computers on campus for all their study. The 3D web-based environment was designed to facilitate study when students were not on campus. This meant that students who did not have access to their own computers, or who had limited access to internet connections outside class time, would not be able to easily participate in the trial. Because of this it was important to know about the students’ use of computers. An extra scale, called the Computer Use scale, was added to ascertain how often students used a computer at home or at polytechnic in their own time, and whether they had access to the internet outside scheduled classes. This scale was added to identify if there were any biases introduced due to students being unable to access the technology outside class time, or unable to use the technology in a way that would enable them to use the web-based resources for study. Appendix A shows the wording of the questions.

The evaluation process focused on the analysis of the student perceptions of the web-based 3D classroom. The scales were used to identify differences between the study group and the control group by looking for patterns in different student

perceptions and the usage of the mediums provided for learning. Because of the small sample sizes, the samples were not necessarily normally distributed, therefore a Mann-Whitney  $U$  test was used to test the hypothesis that the two independent samples from the control group and the study group come from populations having the same distributions. Correlations between student characteristics, cohorts and other factors were also investigated to identify external causes for the differences observed. These are discussed in Chapter Six.

#### **4.4.2 Logs and Notes**

The software selected, Adobe Atmosphere, had a built in logging feature that recorded when users joined a 3D environment and recorded the content of the text-based conversations that took place within the environment. In some iterations of the research, the web-based 3D virtual learning environment was embedded in the Polytechnic Learning Management System, *Blackboard*, in others there were links on *Blackboard* pages to a separate web page that included the embedded 3D environment. *Blackboard* also has the ability to record page views and track student usage.

#### **4.4.3 Artefacts**

All artefacts created during the research were kept for analysis at the end of the research cycles. These included the actual web-based 3D virtual learning environments created. The requirements documentation created, included use cases, prototype designs, personas of potential users, and scenarios for usage. Much of these data were paper-based, in which case they were scanned and saved as digital documents.

#### **4.4.4 Interviews**

In-person follow-up interviews were conducted with a small sample of graduated students who had participated in the 3D learning environments. These occurred after the analysis of the initial data from the WEBLEI, logs, and artefacts and were used to investigate phenomena observed in the data. The interviews provided a more in-depth perspective on the analyses from the survey, and observed outcomes, contributing to the development of understanding.

As the interviews took place after the students had finished their study at the polytechnic there were a number of practical issues involved with contacting them. The WEBLEI included a section for participants to provide contact details and volunteer to participate in follow-up interviews. The students were also contacted through professional organisations, such as programming user-groups, that meet at the polytechnic. Students were approached at these meetings and invited to participate in an interview. In addition, emails were sent to all the addresses the students had entered into the web-based systems when they were enrolled in the programme. Some of these were no longer valid as up to two years had passed since the students had graduated.

#### **4.4.5 Research Focus Questions for Data Analysis**

Thus, the research process involved the analysis of data, gathered from many sources, to identifying directions for each subsequent iteration of the research while seeking answers to the research questions defined in section 4.2. To guide this analysis, the following research focus questions were developed and are answered through Chapters Six, Seven, Eight and Nine.

The first group of research focus questions were designed to answer Research Questions A, to F described in section 4.2. These are focussed on the students' perceptions of their environment and the interactions that took place within it:

1. What are the students' perception of the 3D learning environment?
2. Does the relationship between students' perception of their learning environment differ between students who use the 3D environment and students who do not?
3. What is the relationship between the 3D learning environment and levels of student-to-student interaction?
4. What is the relationship between students' perception of their learning environment and the levels of interaction between student peers?
5. What is the relationship between the 3D learning environment and levels of student-tutor interaction?

6. What is the relationship between students' perception of their learning environment and the levels of interaction between students and tutors?
7. What are the interactions taking place in the web-based 3D learning environment?
8. Are there differences in participation/activity levels for any members of the study group?
9. Does a difference in participation/activity levels affect the student perception of their learning environment?

The following research focus questions sought to develop a deeper understanding of web-based 3D environments for learning. These questions were used to inform the design and creation of more compelling environments for subsequent iterations of the research:

10. What are the learning activities that need to take place in the 3D environment?
11. What are the elements of the designs for future web-based 3D learning environment?
12. What are the features required for web-based 3D learning environments?

These questions were asked of the data, to focus the analysis, provide insight for future iterations of the research and answers to the research questions.

#### **4.4.6 Summary**

Answers to the research questions were sought based on a pragmatist research paradigm. The inquiry strategy followed a mixed method approach concurrently collecting both quantitative and qualitative data over several research cycles. The methods of data collection and data analysis combined elements of quantitative study with qualitative study integrating the information in the interpretation of the results. The research methodology was based on a participatory action research methodology, following a research by design process. The survey instrument design

is based on the WEBLEI, itself arising from a long history of learning environment research instruments, described in Chapter Three. The evaluation methods followed both qualitative and quantitative methods in an approach that provided multiple sources of data and multiple perspectives.

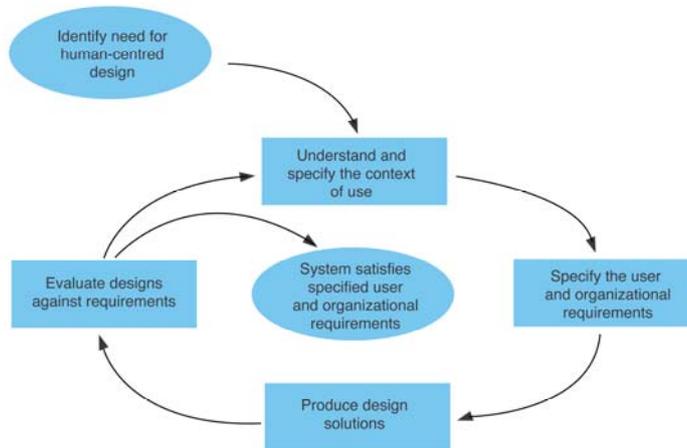
## **4.5 SYSTEM DEVELOPMENT**

### **4.5.1 Development Methodology**

This research project required the development of web pages, installation of software and the development of a new web-based 3D virtual environment using this software. The systems development lifecycles from the interaction design field of human computer interaction were used to guide this process. Software development lifecycles focused on human computer interaction emphasise an iterative approach with the potential end users actively involved at all stages of the development (Preece, Rogers, & Sharp, 2002). This process was consistent with the action research process, participative design strategy, and design-based research methods.

Building an application this way was a new process as the specific software selected was *Adobe Atmosphere*. Details of the selection process are discussed in Chapter Five. This product was first released in October 2003, and was still in beta release when the initial investigations for the research were commenced. This software embodied a new means of interaction through web pages. When this research was started there was very little literature on the design process for this type of environment for learning or any other community support activity. One of the few published studies available was the Hutchworld, a study of the development of a community support centre for cancer patients using a similar product *Microsoft V-Chat*. This also used a participatory approach and followed an iterative development methodology (Farnham, et al., 2000, 2002). This study was used as a guide for a suitable development methodology.

The development methodology selected was an iterative evolutionary prototyping methodology from the field of Human Computer Interaction. This follows ISO 13407 guidance on achieving quality in use by incorporating user centred design activities throughout the life cycle (Sharp, Rogers, & Preece, 2007).



*Figure 4.1.* Human Centered Design Methodology compliant with ISO 13407 (Sharp, Rogers, & Preece, 2007).

This development lifecycle supports multiple iterations, that each include reflection to understand the context of a system, identifying the requirements, designing and building a solution then evaluating the use of the system. This was compatible with the participatory action research practices selected for the research.

#### **4.5.2 Design Principles**

The virtual environment has similarities to and incorporates many of the features found in standard graphical user interfaces, web-based interfaces and of online multiplayer games. The usability design principles for these environments were used as guidelines throughout the design process. These principles were developed by Nielsen et al. (2001) for graphical user interfaces and are: visibility of system status; match between system and real world; user control and freedom; consistency and standards; help users recognise and recover from errors; error prevention; recognition rather than recall; flexibility and efficiency of use; and aesthetic and minimalist design, help and documentation.

The user interaction in 3D virtual environments has been characterised as four universal interaction tasks. These tasks include navigation, or the task of moving through the environment, including the subtasks of way-finding which is the

cognitive component, and travel which is the motor component. The second task is selection, which is the task of choosing one or more objects from a set and is often coupled with manipulation. The third task is the specification of object properties such as position and orientation. The fourth task is system control defined as changing the system state or mode of interaction (Bowman & Hodges, 1999).

The principles of game design in 3D worlds include: third-person presentation, discovery, and exploration, movement versus animation, player control, the use of maps, the use of “weenies”, closed environments, constant positive feedback with sporadic negative feedback, complexity management, and slow bullets (Clarke-Willson, 1998).

“Weenies” is an odd term coined by Walt Disney when designing massive 3D environments (theme parks). He suggested it was necessary to lead visitors through the environment the way you train a dog, by holding a wiener and leading the dog by the nose. Disneyland incorporates obvious “weenies” such as Sleeping Beauty’s Castle that encourages visitors to travel from the main entrance to the central hub.

A user in a 3D environment should be able to navigate through obvious landmarks. The environment design should lead the user through the environment. Since this time there has been a lot more progress in game design and there is now a wide range of literature available on games and simulations in eLearning.

### **4.5.3 The Initial Prototype**

The designs of initial prototype virtual environments were created, informed by literature on presence, theories of learning, interaction in learning, and the pedagogy, andragogy, heutagogy continuum described in Chapter Two. These were used to create user requirements for the software selection process as described in Chapter Five. This was followed by the creation of the introductory worlds for the first iteration of the research. The first trial environment created in 2002 was a proof of concept investigating the technical features of the development environment. In subsequent iterations, many more sketches and actual prototype learning environments were created with the active participation of the participants in the study.

#### **4.5.4 Design Strategy for Incremental Iterations**

The development methodology identified in 4.5.1 involved development of incremental prototypes. Each prototype designed and developed was tested and evaluated to provide information for the design of the next iteration. This meant developing a very simple first world followed by incremental iterations expanding the prototype as understanding of the technology progressed through the evaluation of its use. Each iteration was to include more features to support an increased range of learning activities. Each trial was intended to evaluate how the newly included features worked and to evaluate their potential from a learning and teaching perspective. Chapter Seven presents an analysis of the worlds created, and the features included in each iteration.

This main class world environment was designed for the purpose of conducting classes and independent study on assigned tasks. It was used to gather user feedback, design ideas, and activity information. These were used to inform development of further prototypes of the web-based 3D virtual learning environment for the following iteration of the research. The environment was made available to students studying Human Computer Interaction. It was accessible from within the course *Blackboard* learning portal and from a separate web site.

The initial metaphors chosen for the home class world were a play space and a soapbox. The play space was designed to introduce the tools to people unfamiliar with this method of web-based interaction. The soapbox was chosen as the intention was to use this environment for lecture purposes. Therefore, it was set up to enable a central presenter surrounded by a lot of space for a class represented by avatars to move around in the landing zone.

The soapbox was situated in the base of an amphitheatre with the audience above on stepped platforms located all four sides. The entire scene was enclosed in a box with walls that were easily scaled while gravity was operating. This was designed to prevent avatars falling and losing their location in the environment. The centre was an open space to enable visual navigation.

A gallery was chosen for the second main class world as one objective of this trial environment was to evaluate the effectiveness of the different media available to

be used to communicate the course content. The gallery featured different information media arranged around a stepped meandering pathway. Items which had sound associated were spaced to avoid overlaps with could cause more than one audio track being played at once. Videos were situated in alcoves with individual play controls. The current topic PowerPoint was playing on a prominent noticeboard in the centre of the landing area. Animations plus text and image-based information were scattered around to create a gallery effect, enabling users to browse by moving around in the environment and discover new features without losing their context. The most ambitious version of the main class world was based on a plaza metaphor.

Table 4.1  
*Main Class World Metaphor by Year*

Year	Main class world metaphor
2002	Play space
2004	Soapbox
2005	Gallery
2007	Plaza
2008	Gallery

In parallel with the development cycles of the main class world prototypes, students studying human computer interaction developed their own metaphors and prototype designs of worlds suitable for a virtual education environment. These worlds were linked using teleports from the main class world and from a separate web page that provided a list of links. The designs and design artefacts were analysed, looking for common themes. This analysis plus the feedback from the prototype evaluations and user experiences were used to inform the development of the next version of the prototype for the following stage of the research.

## 4.6 DATA ANALYSIS TECHNIQUES

The research project was to provide support for undergraduate courses in the Bachelor of Information Technology programme at a New Zealand Polytechnic being delivered in a blended delivery environment. There were seven cycles of research involving students. After the initial proof of concept prototypes were developed by the researcher in 2002, the research was expanded to include students. In 2003 one group of third year students from a third year capstone project course completed a design and build exercise using beta versions of the software. This was followed by two iterations where a full class of students used the environment in the paper delivery 2004, 2005. These students had access to a provided main class world scene and were instructed to create their own worlds. The scenario for the world always focused on an aspect of learning environments. In 2005, near the end of the semester during the third iteration of the research, the WEBLEI was administered to all the students studying in the Information Technology programmes. This was the second iteration of the research in which a full class used the 3D web-based learning environment.

The WEBLEI was completed by both the group participating in the study and a control group consisting of the other students studying in the Information Technology programmes. This enabled a comparison between those who had access to the worlds and those that did not. As the researcher was on leave, no data were collected in 2006. The fourth iteration in 2007 involved the same scenario as the third iteration, with a greatly expanded attempt to integrate information and media into the main class world environment. The final iteration of the main class world in 2008 embedded the world as the landing page within *Blackboard*. From 2009 onward, no main class world was provided for the course; however, the students were involved in tours and activities, including building, in other 3D worlds, including Active worlds, Second Life and Wonderland. Table 4.1 shows the research iterations and data collected by year.

Table 4.2  
*Research Iterations and Data Collected*

Iteration	Year	Participating Groups	Data collected	Artefacts Collected
	2002			Software evaluation Design documents Atmosphere world
1.	2003	Student project team	Logs	Design documents Atmosphere world
2.	2004	Full Class	Logs Interview	Design documents Atmosphere Worlds
3.	2005	Control group Full Class	WEBLEI Logs Interview	Design documents Atmosphere Worlds
-	2006	-	-	-
4.	2007	Full Class	Logs Interview	Design documents Atmosphere Worlds
5.	2008	Full Class	Logs Blackboard logs	Design documents Atmosphere Worlds
6.	2009	Full Class	-	Design documents
7.	2010	Full Class Student Project Team	-	Design documents Wonderland World

A number of different types of data and artefacts were collected, and some of these were collected over several years. During this time there were changes in versions of software tools used for analysis, resulting in a number of different products being. A preliminary analysis of the quantitative data was conducted using Microsoft Office Excel (2003, 2007). Further detailed analysis of the data was carried out using SPSS 13.0 for Windows (2004).

A preliminary analysis of the qualitative data was conducted using Microsoft Office Excel (2003, 2007). A further detailed analysis was conducted using nVivo 8 (2009). The qualitative data were coded for themes and key words, and searched to

identify patterns in the data. The interviews were conducted and transcribed by the researcher.

#### **4.6.1 Validity**

Lather (1991) suggests constructing research designs that demand vigorous self-reflexivity. Four ways to encourage this are triangulation, construct validity, face validity, and catalytic validity (Lather, 1991). Triangulation involves using multiple sources of data and multiple perspectives so that if you look at something from a number of different angles, you will see a clearer and more accurate picture. Construct validity refers to awareness by the researcher of the ways in which theories and other constructs are created. Face validity means realizing that what is described or explained rings true. Catalytic validity represents the degree to which the research process focuses and reorients participants toward knowing the situation in order to transform it, thus energizing the participants.

This research employed the techniques described by Lather to ensure a robust research design. Triangulation of multiple sources of data, that included many perspectives, was used to provide a clear picture of the results of each research iteration. A thorough understanding of the theoretical bases of the fields of study involved underpinned the research. The embedded iterative participative action research cycle encouraged frequent reflection on the reasonableness of the outcomes observed. This process facilitated a high level of face validity and catalytic validity.

#### **4.6.2 Reliability of the Research Instruments**

Reliability of the research instruments was determined using internal consistency reliability. This is a method that involves calculating Cronbach's alpha coefficient for each scale within the WEBLEI instrument and for the complete instrument. This coefficient determines the degree of reliability between answers to a group of questions that address a common theme (Cronbach, 1951). Generally, this coefficient will be between 0 and 1, although Nichols (1999) has described a situation in which negative value can occur. The closer the calculated coefficient approaches to 1, the more reliable the data can be considered. Scales with reliabilities of more than 0.70 are recommended when comparing groups and a

reliability criterion of 0.90 is recommended when analysing individual scores (Nunnally & Bernstein, 1994).

#### **4.6.3 Correlation Coefficients**

Pearson's correlation coefficient is used to determine the relationship between two variables. It requires both variables to be measures on an interval scale, and the coefficient is based on the real values. This measure was used to determine the relationships between the various scales and between the scales and demographic factors for the WEBLEI analysis as the scales were all based on a five point Likert scale and the demographic data was based on grouping categories.

#### **4.6.4 Generalisability and Bias**

This research was conducted in a small polytechnic with a very wide student base with a corresponding wide range of motivation for study. The students ranged from teenagers to people in their 40s and 50s. There were those who were seeking to advance their academic qualifications and those who were seeking to retrain in a different field. Many start at the lower level certificate courses to gain entry to the degree courses, some taking only third year papers, as they are enrolled in a Graduate Diploma in Information Technology having either, significant experience in the local industry, or a relevant degree from an overseas university. This leads to a very diverse group with a wide range of needs as learners. This wide range of learner needs and attitudes was a major consideration in the design of the learning activities and the learning environment.

Students were selected based on their access to the environment and participation in the courses using the environment so that only full participation has been evaluated as part of the study group. These are Information Technology courses and all students in the study group had access to home computers with internet connections, 95% of the control group had access to home computers and 92 % of these students had access to computers with internet connections at home to support their study.

The students involved in the study and control groups fitted two distinct profiles in their familiarity with information and communications technologies. The first group was the teenage and young adult group who have grown up using computers in their schooling and use the internet as an information tool, communication tool, and a recreational gaming environment. The second group includes the students who had not been in the schooling system in recent years and were not familiar with the use of the computer or internet for study when they commenced their polytechnic study.

There is a growing body of research identifying that students who have been exposed to the new media and technology landscape while growing up have fundamentally different thinking and processing strategies to those who grew up before the explosion of these technologies into the home. The students defined as fitting in this group are those born approximately between 1980 and 1994. The term digital native has been adopted to refer to this new generation, while those who were not born into this digital world, but have adopted it at a later point in their lives are referred to as digital immigrants (Prensky, 2001).

It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today's students think and process information fundamentally differently from their predecessors. These differences go far further and deeper than most educators suspect or realize. "Different kinds of experiences lead to different brain structures", says Dr. Bruce D. Berry of Baylor College of Medicine. As we shall see in the next instalment, it is very likely that our students' brains have physically changed. (Prensky, 2001, p. 1)

Research is showing that the type of changes brought about through using a computer for two hours a day, five days a week, for weeks on end, involves fundamentally different cognitive functions, different models of activity response, and different models for engaging activities. Quam (2010) describes activities to engage Digital Natives as those that: have high graphics content, presented before text; are fast paced; include multiple stimulus at once; enable random access and brain storming.

Moore (1997) proposed that brains developed through game and web-surfing processes on the computer are actually being retarded by the linear thought processes that dominate current educational systems. He also reported William D. Winn, Director of the Learning Center, Human Interface Technology Laboratory, University of Washington as stating that children raised with a computer “think differently from the rest of us. They develop hypertext minds. They leap around. It’s as though their cognitive structures are parallel, not sequential”.

This research described in this thesis was aimed at developing a new learning environment that would be an engaging environment for students who fitted the digital native generation profile. The study base was a polytechnic with a wide range of students. The actual students who were involved including those; in the trial, those who completed the WEBLEI questionnaire, and those interviewed, did not all come from this group. In the study group, 53% fitted the digital native profile. In the control group, 45% fitted the digital native profile.

#### **4.7 SUMMARY**

This chapter has presented an overview of the research perspective. The reasons for choosing the research methods, the design of the study, the design of the instruments used, and the methods of evaluation were given. The research questions have been identified. A justification for the mixed method approach to research enquiry was made. The role of participatory action research was explained as was the adopted research by design process. The systems development methods followed with the identification of requirements, design, and building of the software was explained. The methods of evaluation were explained as was the use of statistical analysis for the WEBLEI data. The evaluation methods followed both qualitative and quantitative methods in an approach that provided multiple sources of data and multiple perspectives. The research participants have been identified, the environment the research was conducted in has been discussed, including the profile of the student body, and the resulting limitations identified.

The analysis of the data is divided into three chapters, analysis of the survey data, analysis of the design and development artefacts and analysis of the usage and rich data sources. These are presented in Chapters Six to Eight. Chapter Nine

presents a synthesis, discussion and analysis of the research questions presented in Chapters One and Four.

## CHAPTER 5

### SOFTWARE TO CREATE 3D WORLDS

We lived once in a world where the realm of the imaginary was governed by the mirror, by dividing one into two, by theatre, by otherness and alienation. Today that realm is the realm of the screen, of interfaces and duplication, of contiguity and networks. All our machines are screens, and the interactivity of humans has been replaced by the interactivity of screens. (Baudrillard, 1993, p. 54)

#### 5.1 INTRODUCTION

Before creating the 3D environments involved there needed to be a selection of software, the design, and development of prototype environments and an evaluation of the use of these environments. This process followed principles and methodologies from the Interaction Design discipline. This software selection process identified possible software packages to develop the required 3D environments. These were evaluated against selection criteria and a suitable product was selected for the study.

The software required was similar to software used to create multiplayer online games. Gaming software provides rich multiplayer environments that include high quality graphical representations of the players as avatars and embedded multimedia to enable the game play. Contemporary developments in gaming, particularly interactive stories, digital authoring tools, and collaborative worlds, have suggested powerful new opportunities for educational media (Squire, 2003).

The purpose of the selection process was to identify and select a software product that would enable the development of a web-based 3D learning environment to support activities similar to those involved in online games, but focussed on activities to support learning. The software was required to enable the creation of 3D worlds that included mechanisms to provide content using rich multimedia. The software was also to enable the use of avatars to provision user embodiment within

the virtual environment. The avatars fulfilled several functions, including the means of interaction with the world, and the method of communication with others in the world, including awareness of others. The avatars were to be the visual/social embodiment of the learners and teachers providing the way to sense various attributes of the world. The learners and teachers represented by avatars needed to be able to move around, talk to each other, interact with people and content objects within the world. The software was to enable the creation of a new type of online learning environment that would be populated with other learners, teachers and learning materials to interact with. The software selected was used to form the basis for the web-based 3D virtual learning environments created during this research.

## **5.2 SOFTWARE SELECTION**

The selection of software for this study was based on a review of the options available in 2002/2003. It was important to the study that there was continuity in the software used throughout the study, as this was expected to cover a period of up to six years. Once the software was selected copies of all the components were stored to protect the study from the possibility that the software was withdrawn from market or discontinued. This did in fact occur. *Adobe Atmosphere* was the software selected. It was a product purchased by *Adobe Systems* in November 1999 from Altitude Software. It was moved from public beta testing to public release by Adobe in October 2003, and then discontinued from sale at the end of December 2004. Despite this issue the study continued using the already purchased licenses and the backed-up versions of the software.

The selection process in 2002/2003 involved creating a set of evaluation criteria and researching a range of different software products, available, to create 3D virtual environments. These ranged from fully proprietary-leased solutions to open standards- based solutions and software development tools that could be used to develop 3D software. Some of the products available used purpose-built browsers and others were accessed through standard web browsers using plug-ins embedded in the web pages. There were different levels of customization available in the products ranging from those that had a number of predefined objects that could be used for building and those that enabled the designer and builder to create their own objects using the supplied software or third party software. Some enabled the use of third

party products within the environments created. There was a great deal of variety in the facilities for incorporating other media for information content and the methods available to accomplish this.

Development of the evaluation criteria involved considering the environment the software was to be used in and the theoretical foundation of the study. The environment was a small polytechnic in New Zealand that has a student base of domestic students who are often second chance learners and mature students, plus international students from China and other Asian countries. Of the students, 48% were domestic students and only six of these domestic students came to study on the programme directly from completing a University Entrance qualification at high school. The age range for the domestic students involved in the study ranged from 19 to 47, the mean age for this group was 28.4, and the mid-point in the age range was 26.

The aim was to provide an environment that enabled web-based study, included the course content and provided a means for participants to interact with the content and each other. The theoretical base was centred on theories of learning and communication as discussed in Chapter 2. The exploration of the web-based tools was focussed on those that would facilitate increased participation in study through improved interpersonal and group communication.

For the purpose of this study, it was considered important, that costs be minimized and that the software be freely available for individuals to contribute their own designs and worlds to a community of learners. The software needed to be robust and able to be used without intrusive technology interference through technical problems. The ability to include data storage using a database management system was considered essential to enable eventual automation of the learning content and learning management. It was also important that the resulting environment be safe for all users, easily maintained and upgraded, and that continuity of supply could be guaranteed for the duration of the study. A number of different solutions were investigated, before the selection of the final product.

The provision of high fidelity graphics, and realistic animated avatars was considered an important requirement. The research discussed in Chapter Two

suggested the sensory environment was critical to generating a sense of presence. It also highlighted that the sense of presence was an important component for learners to engage in the environment.

Additional factors considered in the selection process included, facilities for multiple builders to participate, persistence of worlds created, mode of interaction, freedom of design, browser integration, ability to connect to databases for content management and media support.

### **5.2.1 Software Considered**

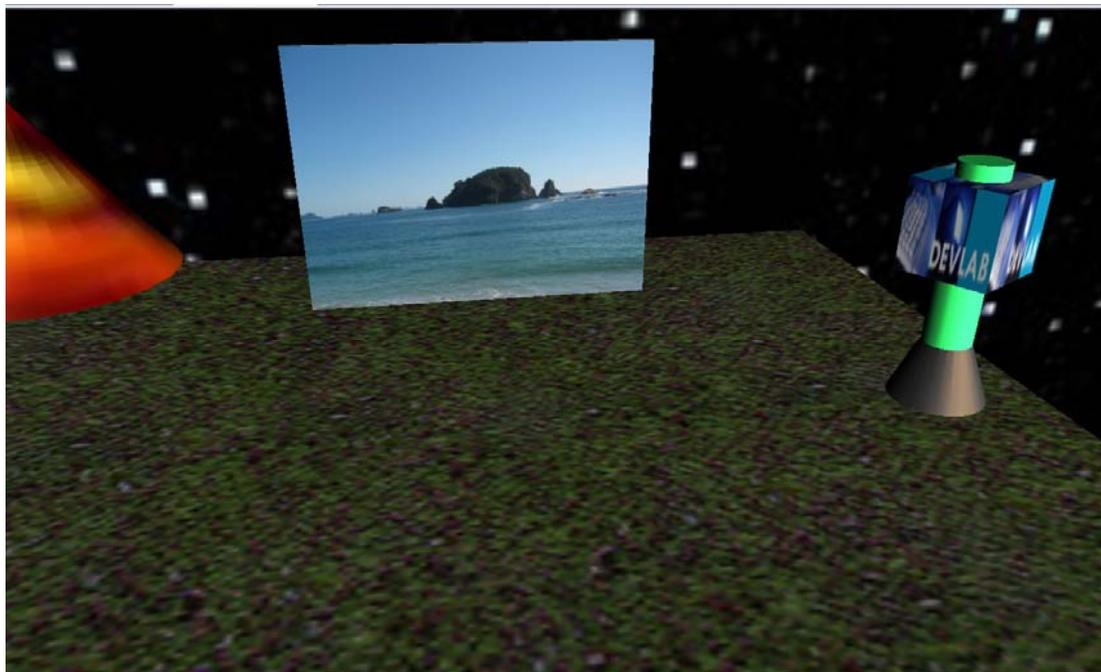
The initial investigation identified a number of available options for 3D virtual environment software products that could be considered. These were *Adobe Atmosphere*, *Active Worlds*, *The Palace*, VRML, *Shockwave*, *Worlds.com*, *Blaxxun*, *Onlive Traveler* and games engines.

*Adobe Atmosphere* was in beta testing and enabled worlds to be built using proprietary builder software, published as web pages hosted on any web server, and browsed to using *Microsoft Internet Explorer*. The worlds were full 3D models that were built from a wireframe designer, and could expand in all three dimensions. Objects within the worlds could be imported from external builders or created as individual models. Any image in jpg or gif format could be applied as a texture. Chat services and synchronisation of avatars was provided through a server that was available under a General Public License (GPL) for installation on any Linux server.

*Active Worlds* was a fully hosted service that enabled in-world building of temporary structures for free. Worlds could expand along the x and y axis but not vertically resulting in a low-rise world spread out over the supplied plain. Buildings were created using supplied textures and supplied objects. These objects included, sounds, images, and animations. Some examples of the 3D objects available were waterfalls, columns, and chairs. The available avatars were supplied by Active Worlds and could not be created by the users. To build persistent structures in Active Worlds it was necessary to purchase or rent "Real Estate" as it is not an open system. The interface was a standalone combined browser/builder and the worlds could not be accessed through a standard web page. There was no opportunity for

people building scenes to connect to a custom database for user management or content management.

The software development languages Virtual Reality Modelling Language (VRML) and *Shockwave* were also investigated however, these required a major programming project to create a usable 3D world, and this programming effort was outside the scope of this study. The development task would have been very large as there were no builders or players available to reduce the development workload. Figure 5.1 shows an example 3D scene built with VRML.



*Figure 5.1.* Example VRML world built with 166 lines of VRML 2 code.

In addition, the W3C consortium was in the process of re-specifying the VRML standards at this time, as the standard in existence when this study was starting had not been successful and was largely unused. The new standard released is X3D which is the ISO standard XML-based file format for representing 3D computer graphics approved as an international standard in 2004, and is the successor to the VRML. X3D features extensions to VRML. The standards for Humanoid animation and language binding to Java were ratified in 2006. Since then

a number of players and builders have been emerging into the public arena. The X3D consortia site currently lists 20 viewers/players, 18 builders/toolkits and 4 collaboration servers (WEB 3D - X3D, 2010).

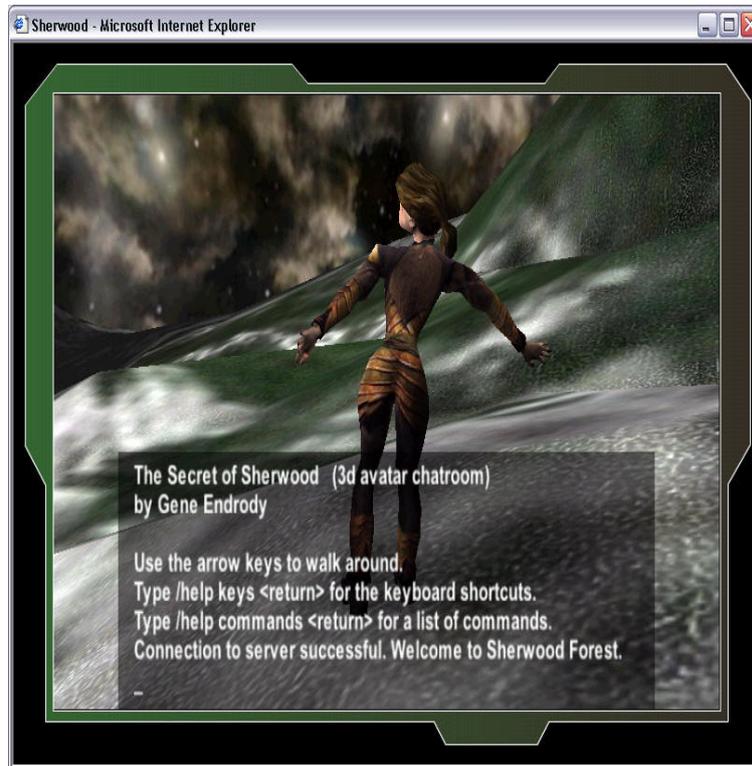


Figure 5.2. Example custom built Shockwave scene from MaidMarion.com 2002.

There were also examples where groups were engaged in building custom 3D environments, one such example was being developed by *Dreamworks* using *Shockwave*, enabling the environment to be included in a standard web page. Figure 5.2 shows a screen capture taken of MaidMarion.com in 2002, and the project was described on the associated website in 2002 as follows:

'MaidMarian.com is an on-line experiment by dreamboat Multimedia. The goal is to create a browser based multi-user 3D MMORPG without requiring the download and installation of cumbersome client software. Just click a link, and you're in. After some research, we have determined that

Macromedia's Shockwave 3D has the most potential to help us meet this goal. The Maid Marian Experiment is the result. (MaidMarion.com, 2002)

*The Palace* was abandoned software that enabled a 3D like group chat experience, it is however more realistically a 2D chat program. The player was embedded in an ordinary web page. The worlds consisted of linked scenes, like rooms, these scenes were static. Moving to another scene was accomplished through portal hyperlinks. The users were represented by 2D avatars that moved through the scenes. The player software was free; however, there was no support available. The server software was not readily available, although there were interest groups running their own servers, these were not freely available to new world builders. Figure 5.3 shows a screen capture of *The Palace* player in use in 2003.



Figure 5.3. ThePalace.com 2003.

To enable permanent creation of controlled access chat rooms access to a copy of the server software was required. Users in a given room could chat with others in the same scene. Names appeared above each avatar. The mode of communication was text chat with speech bubbles appearing above the avatars. There was no database connectivity and the only types of media supported were images and sound. The Palace was described on their website in 2003 as follows:

We are thepalace.com. We are a group of volunteers with no association to the now-defunct Communities.com. We do not own the Palace software. We are not a company. We simply run thepalace.com domain name, and offer several quality Palace servers (listed under "Our Palaces" on the left side of this page). ThePalace.com loves, supports and respects the Palace community. Our intention is not to be the sole "hub" for Palace space, but rather to provide a good starting point full of great links, useful information and timely announcements. If you know of good resources you would like to see added to this site, please contact the webmaster at the address below. (ThePalace.com, 2003)

The other environments considered included fully hosted 3D community environments *Worlds.com* and *Blaxxun* which were marketed under a membership system. Figure 5.4 shows scenes from a world created in 1998 using *Worlds.com*. To participate in these worlds, individuals were required to join and a membership fee was payable to continue participating after an initial evaluation period. Licenses for building and privately hosting worlds, were available at a substantial cost. The cost to students and the Polytechnic meant these options were not suitable.



Figure 5.4. Bowie World 1998 created with Worlds.com (Khz, 2010).

There were also other environments available, which were 3D environments embedded as plug-ins in standard web pages. For example, *Onlive Traveler* from *Digitalspace* which supported multi-user, synchronous audio communication was released in April 2003 under a creative commons license; however, unlike other 3D virtual world applications, *Traveler* avatars were lip-synched talking heads as shown in Figure 5.5.



*Figure 5.5. Onlive Traveler 2004.*

Games engines were considered briefly, however they presented considerable cost overheads for the purchase of development licenses and in development time and effort. Potential solutions that had high associated license or development costs were excluded early in the process as there was no budget to accommodate such costs, in addition there was limited time and resources available for development of new software.

After this initial survey a shortlist was created with the products that met the criteria for cost, interactive features, realism and development time. This list consisted of Active worlds and Adobe Atmosphere. These were investigated in more depth.

### 5.2.3 Adobe Atmosphere

In 2003, *Adobe Atmosphere* was a 3D world program that consisted of a server, a designer to build the worlds, a standalone player and web page embedded player. The software was in a late beta stage with a strong user community experimenting with the product. The beta versions of the building software, server software, and players were all available for free download. The product was released in October 2003, at which time the server software was removed from public availability, the builder software was only available for purchase or as a download of a time-limited one month trial version, the standalone player was withdrawn. The embedded player remained freely available for web pages and PDF readers. The builder cost around US\$399 for a commercial license and there was an education price of \$99, however the *Adobe Atmosphere* product was only offered for sale in the United States of America, it was not obtainable in New Zealand and it was not possible to purchase a class set of licenses for students to use. People registered as beta testers received a free license, which meant that as the researcher was a registered beta tester, there was one full builder license available to use. However, the later beta versions continued to be able to be used even though they were no longer available to be downloaded. The following is the product information on the Adobe website in 2004:

This new embedded multimedia type gives the web or document designer the ability to present a rich variety of interactive content, including three-dimensional objects, sound, streaming audio and video, SWF animations, and physical behaviours, all within the context of a live theatre performance. (Adobe Atmosphere Product Information, 2004)

The worlds could be hosted on any web server, the proprietary chat server software to enable the chat facility and coordination of the avatar movements could be hosted on any web connected Linux server. This enabled anyone with access to builder software, and the internet address of a chat coordination server, to create worlds for public or private use. The landscape was a full 3D axis. The start point for building was the same as any 3D model, an empty canvas with wireframe building tools. Movement within the worlds was also fully 3D with the avatars having the ability to move in any direction. Players had the ability to control a

number of features as shown in the screen capture of the help page in Figure 5.6. It was possible to turn gravity on and off, and turn collisions on and off. When gravity was on, avatars had to stay on top of a solid surface or they would fall into empty space. With collision turned off, the avatars were able to walk through walls and into the centre of solid objects.

Table 5.1.  
*Adobe Atmosphere Player Controls, Image from the Software Help*

Atmosphere Player Toolbar Buttons		
Icon	Name	Description
	Collide toggle	Enables collision detection in the environment
	Gravity toggle	Enables gravity in the world
	Show My Avatar toggle	Shows your avatar in the environment
	Chat	Enables chat mode and opens the Chat palette
	Controls	Opens the Controls palette which may include custom controls
	Preferences	Opens the Preferences palette for setting Player preferences
	Users	Opens the Users palette which lists the other users in the current environment
	Avatars	Opens the Avatar palette where you can change the current avatar
	Bookmarks	Opens the Bookmarks palette which stores bookmarks of favorite sites

Conversation with others was not based on the proximity of the location of other avatars; it was based on the Universal Resource Location (URL) of the web page that contained the world. This enabled users to chat with others in the same world whether they were currently in the camera view or not. It also meant that players could not see or chat with other players who thought they were in the same world, if they had used different mixes of upper and lower case when typing the URL of the web page. All conversation was in the separate text chat window; there was no speech bubble interface, or text-based identification associated with avatars. The worlds supported media such as images, 3D objects created with 3rd party modelling software, sound, movies, and streaming media.

It was possible to connect to databases containing information through a standard web application interface and plug-in integration with web browser. This enabled possible future directions to include content management and learner management through databases.

### 5.2.3 Active Worlds

*Active Worlds* was described on their website in 2003 and was still described this way in April 2008 as follows:

Active Worlds, the web's most powerful Virtual Reality experience, lets you visit and chat in incredible 3D worlds that are built by other users. Think you have what it takes to build your own world, or Virtual Reality game? Active Worlds is the place for you, where in minutes you can create fascinating 3D worlds that others can visit and chat in. The Active Worlds Universe is a community of hundreds of thousands of users that chat and build 3D virtual reality environments in millions of square kilometres of virtual territory. Take a quick look at some of our satellite maps, and see how our community has grown over the years. Launch the free software, and come check us out for yourself, you'll be so amazed at how vast our virtual reality universe isn't

Active worlds home page accessed 2003 and again in April 2008.  
(ActiveWorlds.com, 2003)

*Active Worlds* is proprietary software and offered internet access through a purpose built browser that was downloaded by user request. Figure 5.7 shows a screen capture of the standalone payer for *Active Worlds* in use in 2008. It had a guest sign-on which allowed free access, to browse, and to build temporary structures. There was also paid citizenship that allowed users to have customised avatars for a monthly fee. Both of these types of user were accessing public worlds hosted on *Active Worlds* Servers.

It was also possible to purchase licenses to construct permanent sites, and to host the server software on private servers. The license was \$650 per year for a hosted classroom for 20 synchronous users in 2003. This was the entry level educational pricing for a hosted service from the *Active Worlds* website April 2003. It was also possible to purchase an *Active Worlds* license to host the environments on independent servers starting at \$2000 for 50 simultaneous users (ActiveWorlds.com, 2003). In addition, it was possible to purchase a license to install the software on a server hosted outside *Active Worlds*. There was no standard web browser plug-in

available in 2003, however this was changed and an *ActiveX* browser control was available in 2008, enabling the worlds to be accessed through a web browser.

Although, buildings were able to be created using the free access type of membership, these were not permanent, as all buildings created in public areas were able to be altered and removed by any other user. The licensed versions allowed permanent buildings that could not be altered and enabled access to be restricted to specific groups of users.

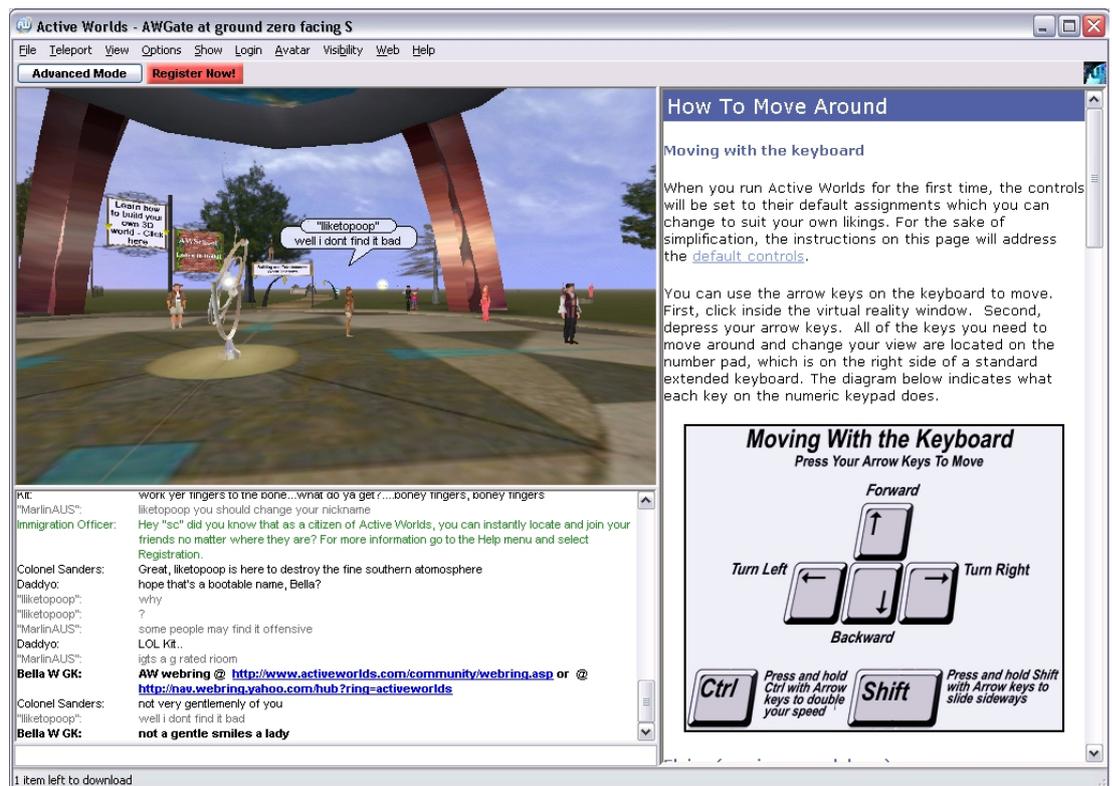


Figure 5.6. Active Worlds web site accessed April 2008.

The landscape was 3D and resembled a planet like surface which was essentially flat with structures built on it. Users had the ability to teleport to other locations. The mode of communication in the standalone browser was text chat. A custom-built web page was able to be displayed inside the stand alone browser. Speech bubbles appeared over avatars heads, in addition to the chat showing in the chat window. It was possible to have private and group chat, chat was enabled in a user set proximity zone.

The worlds were built with prebuilt supplied objects and surfaces, there was no facility to import 3D objects created with other software, although images, sounds, and animations could be imported. There was no scripting facility to connect to databases.

#### **5.2.4 Selected Software Adobe Atmosphere**

The 3D world technology *Adobe Atmosphere* was selected to create the basis of the virtual education environment. This product enabled the development of rich 3D environments with sophisticated graphic, lighting, and physics effects that can be embedded in standard web pages using a free plug-in (Chard, 2004c).

The worlds were built using *Adobe Atmosphere* builder software which was available for free 30-day trial download from Adobe. It was a relatively open system, the community server was available under an Open Source license to be hosted on any compatible internet server, and the player was freely available, although with the public release the free builder license was limited to a 30-day trial.

*Adobe Atmosphere* worlds could be hosted on any server, worlds could be linked together using teleport links from within the worlds, they could also be linked through standard URLs, and they could be linked to standard web pages. The worlds could be customized to include automated actions and user initiated actions using Java Script. This enabled considerable flexibility in behaviour and animations within the worlds. Live video and audio streams could be incorporated into the environments, enabling voice and video presence.

*Adobe Atmosphere* was unique in that it enabled the builder to create 3D virtual worlds that expanded in all three dimensions, vertically, as well as horizontally, and presented a very sophisticated graphical environment (Dickey, 2003). The environment was published as a component of an ordinary web page; this provided a very broad scope for the integration of information with the environment.

### 5.3 AVATARS

Avatars are used to represent people in 3D worlds. In *Adobe Atmosphere*, the avatar being used was identified by a URL pointing to the avatar file which was hosted on any web server. Avatars were also sub-worlds in *Adobe Atmosphere*, which could be created by anyone with access to the builder, and as long as the files were hosted on the internet, they could be used to represent people in the worlds. There were also third party 3D building products available to create avatars and objects to be included in *Adobe Atmosphere* worlds. These were the same 3D building products commonly used by computer game manufacturers. Avatars could be animated using scripting languages, and often showed body movements and gestures. This enabled a great deal of flexibility for people to create and use individual representations of themselves and communicate using “body language”. People could also create their own worlds as meeting places. The wider community associated with *Adobe Atmosphere* freely shared their avatar creations, these ranged from small snails, to large cars, boats containing people, and even a Mars rover. There were many different types of people, animals, and hybrid creatures used. The users of our worlds were free to create or use any avatar they chose. There were no restrictions imposed by the staff, however the technology did impose some limitations.



Figure 5.7. Examples of static avatars.

The avatars with many actions and animations were large files that required a significant download time. Each person in the world, was sent the avatars of all the other participants, when a world was loaded. This meant that the avatars had to be hosted on a website accessible to all the participants and that everyone had to have the bandwidth to enable the downloads to proceed. Some users preferred the smaller download files and a range of less functional avatars were available for users to select if the avatars were taking too long to load. Figure 5.7 shows some of the static avatars, with smaller download times. Figure 5.8 shows some of avatars with the more sophisticated graphics and movements.





*Figure 5.8.* Examples of avatars with movements.

Another consideration was the size of the avatars, in terms of how big they were relative to other objects in the world, some avatars were literally equivalent in size to one building brick in a world, and another would be the size of a whole building in the same world. This was one of a number of issues related to scale that arose with the worlds created.

#### **5.4 BUILDING MECHANISM**

The builder software was supplied with examples worlds and a collection of libraries. Figure 5.9 shows an example world supplied with the builder software. The libraries included texture files to be applied to wire frame objects, and 3D objects such as tables, chairs, and clocks. Scripting libraries contained scripts to enable actions, such as movie controls, fog generation, opening doors, and playing sounds when in proximity to an object. The builder software also allowed the importing of image files for use as textures, and 3D objects created with other building software.



Figure 5.9. Example world supplied with the software.

Building a world consisted of creating a platform, then adding wire frame shapes, to be covered in textures to create objects within the world. Figure 5.10 shows the wire frame view of a student created tree house world. Another way of adding objects to the worlds was to add pre-built 3D objects. Figures 5.11 through to 5.15 show some of the textures and objects used in the 3D worlds during this research. The objects in the worlds then had actions added to them by attaching scripts to them. Figure 5.16 shows a script to play a sound track when an avatar moves close to an object.

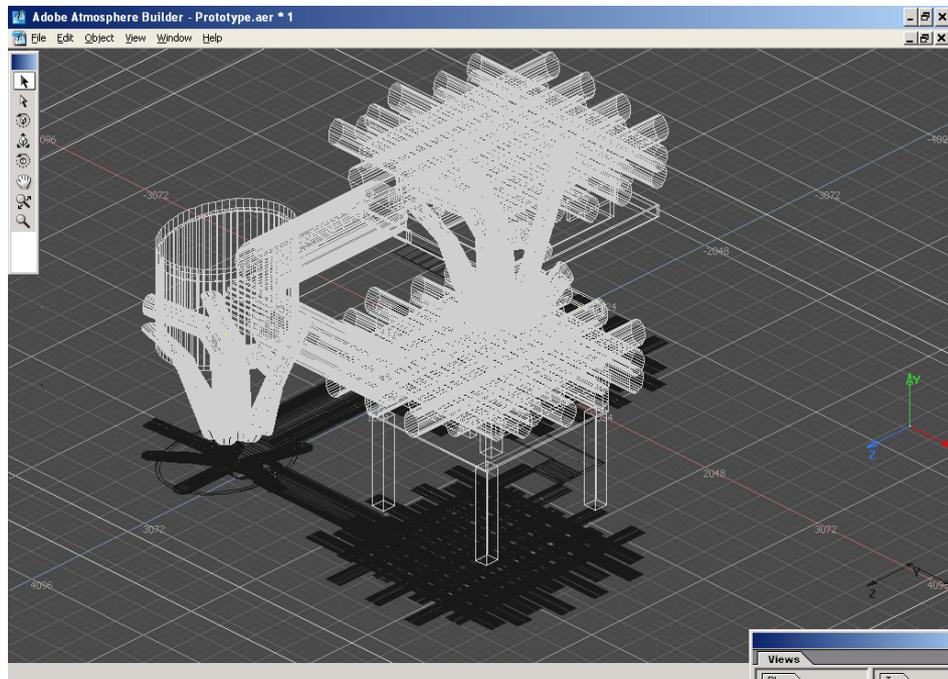
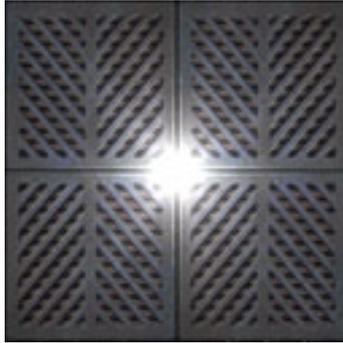


Figure 5.10. Example wire frame model of a student created “tree house” world.



*Figure 5.11.* Example texture supplied with the software, used on floor surfaces.



*Figure 5.12.* Example 3D object (Balloon).



*Figure 5.13.* Example 3D model of SUV showing 3 different views.



*Figure 5.14.* Example image imported into a world.

to move, click in the scene  
then use the arrow keys

to jump hold shift and the up arrow key

to change your nickname  
select preferences

to change your avatar select one from  
[www.devlab.ac.nz/atmo/avatars.htm](http://www.devlab.ac.nz/atmo/avatars.htm)  
and paste into the chat input field

to fly turn gravity off

to chat click in the bottom bar  
of the chat window then type

Figure 5.15. Example graphics file used as a surface texture to act as help for new players.

```

myVoice = Sound("martian_voice.mp3");
vwWall = world.find("../VirtualClass");
myVoice.position = vwWall.position;
myVoice.volume = 4;
myVoice.repeats = 10;
myVoice.play();
myVoice.near = 10; //the distance within which the sound will always be at your
maximum volume
myVoice.far = 50; //the distance beyond which the sound will not be audible.
myVoice.play();
chat.print("Example 2: There is a martian in the Virtual class sign");

```

Figure 5.16. Script to play sound.

The final step, to complete the world and give it a realistic appearance was to light the scene by placing light sources in the world, then rendering the scene. The calculations to light a scene were computationally intensive and it was not uncommon for the lighting to take more than eight hours to render for a scene that included a number of objects. Once the world was completed, it was published, and ready for users to visit. Figures 5.17 and 5.18 show the same world, Figure 5.19 shows a range of views available in the builder with some of building tools available. Figure 5.20 shows the same world published and accessed through a browser, with two participants' avatars visible and showing in the user list.

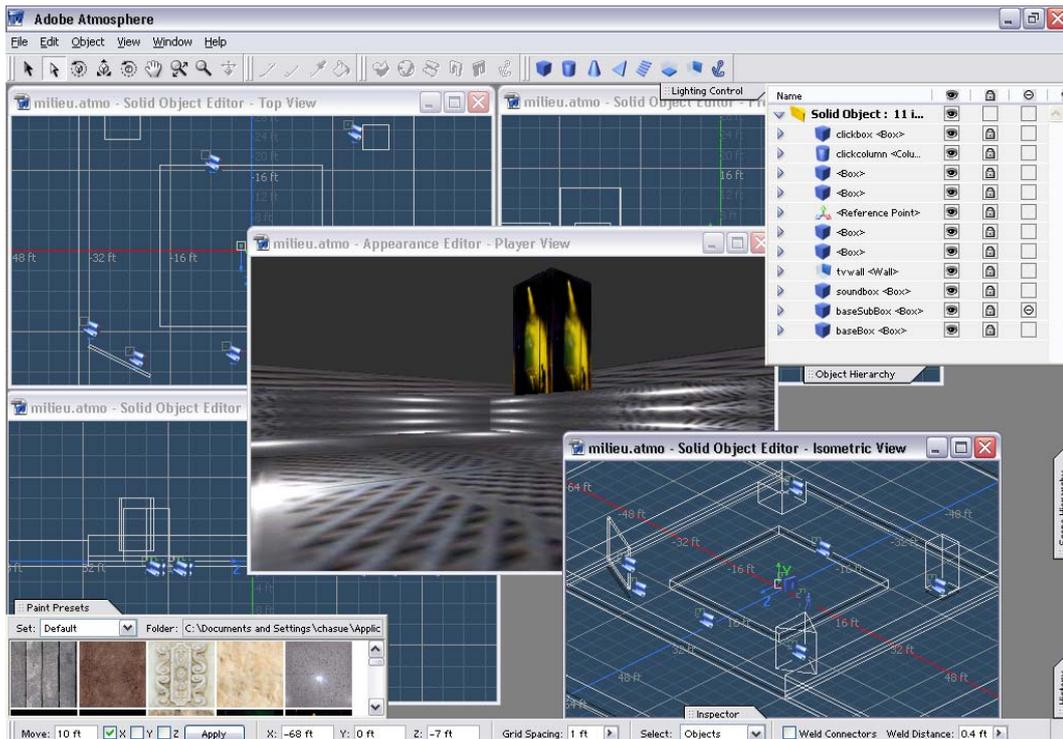


Figure 5.17. Builder showing different wire frame and textured views. (Figure 5.18 shows the result in player view).

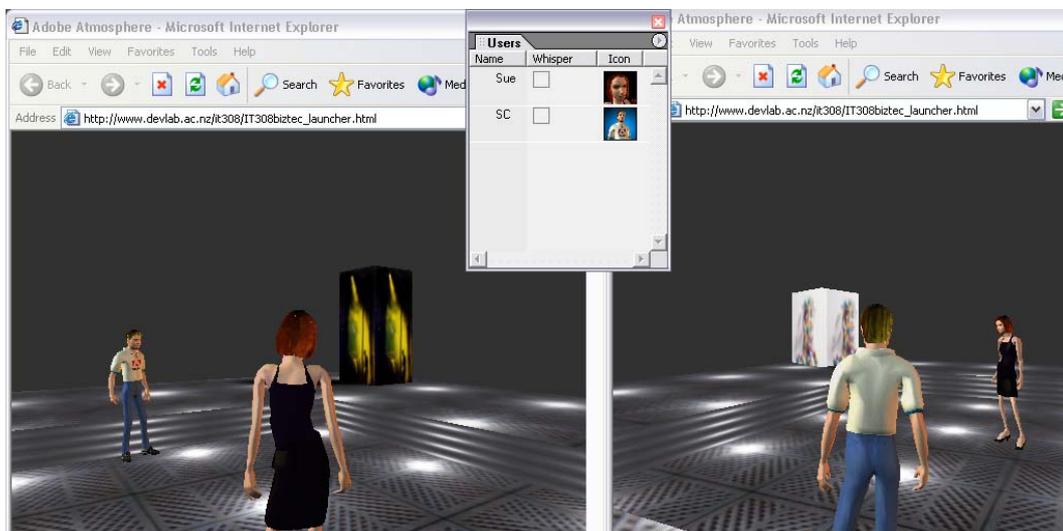


Figure 5.18. Player view of Figure 5.17 shown in a browser.

## 5.5 CURRENT DEVELOPMENTS IN 3D VIRTUAL WORLD SOFTWARE

Since 2003, a number of new 3D virtual world systems have been or are being developed, both in the commercial space and in the open source community. A hosted service that has been developed and has gained prominence is *Second Life* which has featured widely in popular media (Cagnina & Poian, 2007; Craig, 2006; Kim, Lyons & Cunningham, 2008; Making a Living in Second Life, 2006). *Second Life* has many of the features of *Active worlds*, with an updated graphics capability, and incorporates an economic model that requires participants to pay an entry fee to participate fully in the environment.

There is also other virtual world software currently being developed in the Open Source community and now available in alpha releases. This includes *OpenSim* an open source community project, that is compatible with *Second Life* browsers and objects (OpenSim, 2008) and *Open Wonderland* an open source project originally sponsored by Sun Microsystems and currently supported by the Wonderland Foundation. Wonderland enables application sharing within the worlds (Open Wonderland, 2007). There are also initiatives to allow hyperlinked 3D virtual worlds such as the *Open Cobalt* project based on the *Croquet* open source development (Lombardi, Dougan, & McCahill, 2007).

## 5.6 SUMMARY

The software selected for this research was *Adobe Atmosphere*; however, this software has changed over the duration of the study. The initial analysis was performed in 2002, with final selection of the software made in 2003. At this time, *Adobe Atmosphere* was available as a beta product which was still somewhat unstable. The server was not obtained until November 2003. This meant that the initial prototypes created earlier in 2003 were not able to be used for chat or the display of avatars. The final release product available from October 2003 was stable; however, the builder licenses for the free trial builder were restricted to one-month trial. The full builder product was only released for sale in the United States, this meant that it was not possible for the polytechnic to purchase a class set of licenses for the full product. The result of this was that the aim of having all users able to freely build worlds was only partially realised as they had the option of using a one-

month trial version to build their worlds or using a late beta which may be unstable. There were substantial resources provided by Adobe and the user community. This included an active support forum, providing tutorials, other worlds to explore and components to be integrated into the worlds.

The software did provide easily customisable worlds with very good graphics and active components, enabling students and staff to create a range of interesting scenes. Web page integration enabled easy user access to the worlds and the active wider community using the product provided many additional models and scripts to enhance the worlds.

## CHAPTER 6

### RESULTS FROM THE USE OF THE WEBLEI

The rules of the universe that we think we know are deep buried in our processes of perception. (Bateson, 1979, p. 35)

#### 6.1 INTRODUCTION

This research involved the creation of an initial prototype project in semester 2, 2002. This was used to evaluate the web-based 3D virtual world software and its performance in the polytechnic environment. The next stage involved a trial with a small group of students in 2003, followed by the introduction of the software into the learning environment. From 2004 through to the end of 2008 the *Adobe Atmosphere* 3D virtual world software was used as part of the blended delivery environment in a third year Human Computer Interaction class. The lecturer provided a 3D virtual main class world, a scene that included links to web-based resources such as lectures and assignment details. Early in the course, the students in this class created their own individual worlds that were linked to the main environment through teleports. From 2009, the range of 3D virtual world software was expanded to include *Active Worlds* and *Second Life*. In 2010, a pilot project was run to trial *Open Wonderland*, with plans to include it from 2011, as a replacement for *Adobe Atmosphere*. Towards the end of Semester 1 in 2005, the WEBLEI survey was conducted to measure student perceptions of their learning environment. The data collected were analysed seeking answers to specific research focus questions one through eight, identified in Chapter Four section 4.4.5. These questions related to the student usage and perceptions of the web-based 3D virtual learning environment.

#### 6.2 SURVEY INSTRUMENT

The WEBLEI was selected as a suitable instrument to study the 3D worlds being used for this research, as it is targeted for web-supported and web-based learning environments, and is designed for a tertiary environment. In addition, it is designed to measure learning effectiveness in terms of a cycle that includes access to materials, interaction, students' perceptions of the environment, and students'

determinations of what they have learned (Chang & Fisher, 2001). This cycle is appropriate to the 3D web-based virtual learning environment; which includes the accessibility of the learning materials; interactions that take place, effectiveness of these interactions. In addition, it includes the students' perceptions of the environment and the learning that takes place. Minor changes were made to the wording of the survey after trials with small groups of local students highlighted some areas of confusion. Several of the questions that named specific communication technologies such as email were altered to reflect the broader range of communication technologies available in the 3D virtual learning environment.

The surveys were distributed on paper during class sessions by teaching staff who were not involved in the study and the data were analysed using SPSS 13.0 for Windows (2004). The extra scale of Computer Use was administered with the WEBLEI.

The reliability analysis gives an idea of the extent to which items in the same scale of a learning environment instrument are related to each other. The Cronbach alpha reliability coefficient measures the internal consistency of each scale and is based on the average inter-item correlation. All values above 0.60 obtained through this calculation are considered to be acceptable (Nunnally & Bernstein, 1994). As shown in Table 6.1, in this study, the alpha reliability coefficients for the four scales in the WEBLEI survey ranged from 0.86 to 0.95.

Table 6.1  
*Internal Consistency (Cronbach Alpha) and Discriminant Validity (Mean Correlation of a Scale with the Other Scales) for WEBLEI*

WEBLEI Scale	Cronbach alpha	Mean Correlation
Access	0.86	0.38
Interaction	0.87	0.36
Response	0.88	0.43
Results	0.95	0.65

N = 49

The discriminant validity determines the extent to which a scale measures a unique dimension not covered by other scales in the instrument and is often used in validation of learning environment questionnaires. The discriminant validity was assessed as the mean correlation of a scale with the other scales. The discriminant validity of the modified version of the WEBLEI ranged from 0.36 to 0.65 for the four scales.

Chang and Fisher (2003) reported alpha reliabilities of the WEBLEI scales from 0.68 to 0.87 and mean correlations that ranged from 0.37 to 0.49. Based on these results, the modified version of the WEBLEI was a valid and reliable instrument for this study although the scales were somewhat overlapping.

The WEBLEI was used in 2005, as part of the evaluation for this cycle of this research, and the results were used as part of the feedback to inform the development of the main class world for the subsequent iterations of the web-based 3D virtual learning environment. Five groups of students participated in this evaluation, only one of the groups had been participating in the trial of the web-based 3D virtual learning environment. All students had blended mode course delivery with in-person classroom components and web support via *Blackboard* resources.

### **6.3 DESCRIPTIVE STATISTICS**

The WEBLEI survey was conducted and survey responses were collected from all students studying in the Information Technology programmes, and then divided into two groups, those that were involved in the trial of the web-based 3D virtual learning environment and those that were not. The survey was conducted towards the end of the 2005 trial. This was the third iteration of this research project and the second time the web-based 3D learning environment was used with a full class.

The control group consisted of students who had access to similar web-based resources, but no access to the web-based 3D virtual learning environment. The group was further divided into four sub groups. These represented the different student cohorts, by year, and further separated into those studying towards a diploma, and those in a degree course. This was their first semester in courses that included web-based components, so there were 11 students in the control group who were new

to using web-based learning resources.. The response rate varied from 100% to 58% across these individual sub groups. Inevitably, some of the sub groups were small, however, there were 38 valid responses in total that constituted the control group.

Additional valid responses came from the study group and totalled 11. Eleven of these responses were from students in the study group out of a possible 17 students involved in the study at the time, giving a 64% completion rate for this group. Of course, the results are limited by the small size of the sample; however, the mean scores for each group indicate differences in student perceptions. In total there were 49 responses from a possible 71 students enrolled in the courses at the time the survey was conducted giving a 69% completion rate overall.

As discussed earlier, the WEBLEI is designed to measure four separate scales to more accurately identify student participation and engagement with their learning environment and their utilisation of the resources available to them in this environment. The four scales described earlier are Access, Interaction, Response, and Results. Demographic data and students' use of computers were collected at the same time.

Analysis of the student responses using the mean scores from the study indicate that the study group perceived this enhanced web-based environment more favourably than did the control group of students perceive the standard web-based learning environment (see Table 6.2). However, there remained questions as to the possible cause of this effect. Was it due to the novelty of the environment or to the participating students' investment in developing the web-based 3D virtual environment through the use of participative design practices, or was there another outside factor affecting this particular sub group?

Table 6.2  
*Mean Scores for the Study and the Control Groups*

Descriptive Statistics by Control and Study Group						
Group	N	Computer Use	Access	Interaction	Response	Results
Study	11	4.05	3.62	2.81	3.52	3.78
Control	38	4.64	3.27	2.29	2.86	3.08

### 6.3.1 Computer Use Scale

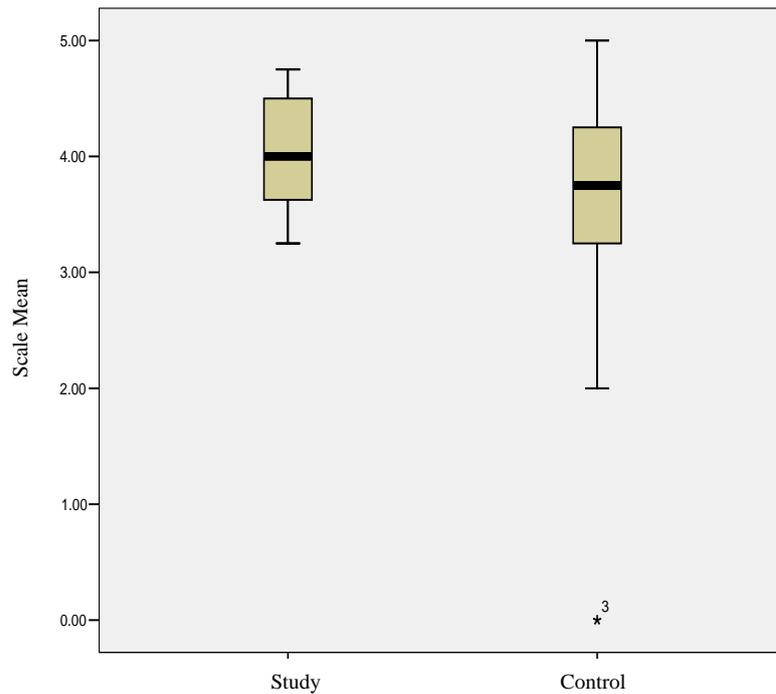
To investigate whether the difference in student perceptions of the learning environment was caused by the simple factor, lack of access to a computer and the internet, and therefore a lack of access to the web-based materials, a Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the Computer Use scale on the WEBLEI.

This group of questions included: “I use my home computer”; “I use the internet”; “I log on to *Blackboard*”; “I log on to *Blackboard* from a computer that is not in a classroom”. The items did not include any questions specific to the trial of the 3D web-based virtual learning environment, removing the possibility of bias caused by a targeted question that the control group of students would have rated as a low score. These items were rated on a five point scale: “Daily”-5; “Three times a week”-4; “Once a week”-3; “Once a month”-2; “Less than once a month”-1.

Table 6.3  
*Group Means, Standard Deviations for Computer Use Scale*

Group	N	Computer Use	
		Mean	Std Deviation
Study	11	4.05	.50
Control	38	4.64	.91

As shown in Table 6.3, the mean for the study group on the Computer Use scale was 4.05 and the mean for the control group was 4.64. A Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the Computer Use scale. The results of the test for the Computer Use scale were in the expected direction; however, the difference was not significant,  $z = -1.401$ ,  $p > .05$ . The study group had an average rank of 30.27, while the control group had an average rank of 23.47. This indicates that lack of access to a computer to use, was not a significant factor in the differences observed between the two groups.



*Figure 6.1.* Comparison of means for Computer Use scale.

There was a high level of similarity in the perceptions of the study group members (see Figure 6.1), indicating that the study group made very similar use of computers and all had good access to computers to use. The control group had a much greater range of perceptions indicating that some of the members of this group had difficulty accessing computers to use, while others had very good access.

### **6.3.2 Access Scale**

The mean scores on the Access scale were then investigated. The means were 3.62 for the study group and 3.27 for the control group (see Table 6.4). This indicates that students in the study group on average responded “often” to “sometimes” to items in the Access scale, meaning that they agreed they could access the web-based learning materials in their environment in a convenient and efficient way providing them with autonomy in their access to the materials.

Table 6.4  
*Group Means, Standard Significance for Access Scale*

Group	N	Access Scale	
		Mean	Std Deviation
Study	11	3.62	.43
Control	38	3.27	.59

Students in the control group on average responded with “sometimes” to “often” indicating they were less in agreement but generally still satisfied with their access to the web-based learning materials in their learning environment, and the autonomy in access to learning materials. The items in this scale focused on access to the learning materials with questions such as “I can access the online learning activities at times convenient to me”, “I am allowed to work at my own pace to achieve learning objectives” and “The flexibility allows me to spend more time learning”.

A Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the Access scale. The results of the test for the Access scale were in the expected direction and significant,  $z = -2.191$ ,  $p < .05$ . The study group had an average rank of 33.27, while the control group had an average rank of 22.61. This indicates that the factors identified in the Access scale, related to the ability to access the web-based learning materials in convenient and efficient way providing them with autonomy in their access to the materials, did contribute to the overall difference in the perceptions of the learning environment.

As shown in Figure 6.2, there was a high level of similarity in the perceptions of the study group members, indicating that members of the study group perceived their access to activities in a very similar and positive way. While the control group had a much greater range of perceptions indicating that some of the members of this group perceived difficulties in access to learning activities while others perceived their access to learning activities to be good.

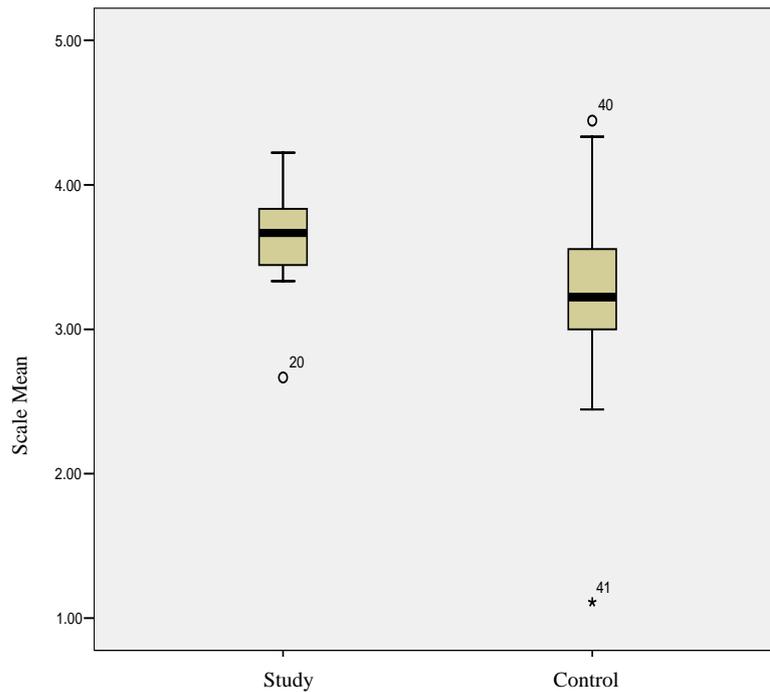


Figure 6.2. Comparison of means for Access scale.

### 6.3.3 Interaction Scale

Table 6.5 shows that the mean scores on the Interaction scale were 2.81 for the study group and 2.29 for the control group. This means that the study group on average responded “sometimes” to “often” indicating that students believed they were able to participate and interact regularly with each other and the teacher enhancing their ability to be successful and effective learners in this environment.

Table 6.5  
Group Means, Standard Deviations for Interaction scale

Interaction Scale			
Group	N	Mean	Std Deviation
Study	11	2.81	.79
Control	38	2.29	.83

The control group on average responded “seldom” to “sometimes” indicating they did not believe they were able to participate and interact regularly with each other and the teacher and that this was detracting from their ability to be successful

and effective learners in their learning environment. The items in this scale related to the ease of communication between students and between students and tutors.

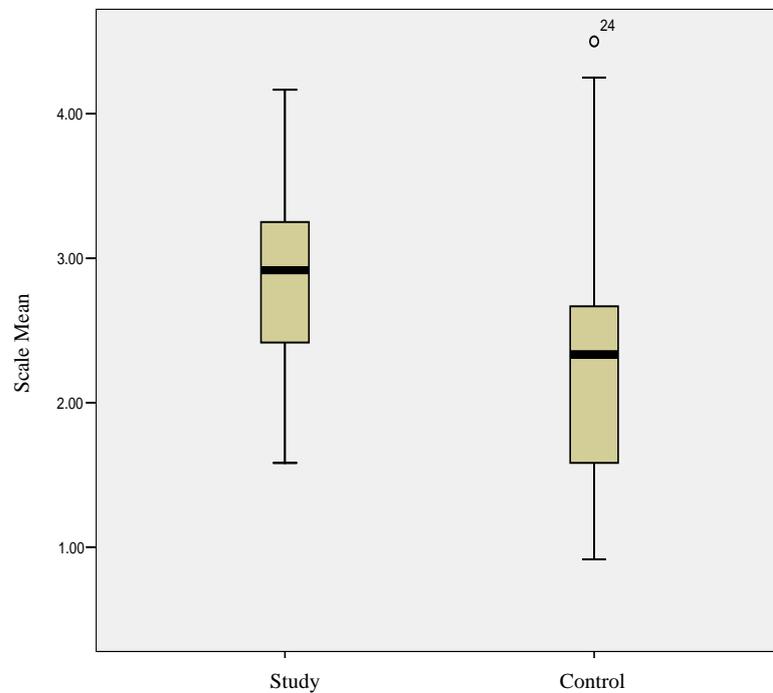


Figure 6.3. Comparison of means for Interaction scale.

A Mann-Whitney  $U$  test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the Interaction scale. The results of the test for the Interaction scale were in the expected direction and significant,  $z = -1.980$ ,  $p < .05$ . The study group had an average rank of 32.50, while the control group had an average rank of 22.83. This indicates that the factors identified in the Interaction scale, relating to the students ability to participate and interact regularly with each other and the teacher did contribute to the overall difference in the perceptions of the learning environment.

There was also a greater range of perceptions for the study group on this scale than the previous scales (see Figure 6.3), indicating a wider range of perceptions regarding their ability to participate and interact. The control group had an even greater range of perceptions indicating that some of the members of this group

perceived difficulties in participating and interacting, while others perceived adequate levels of interaction and participation.

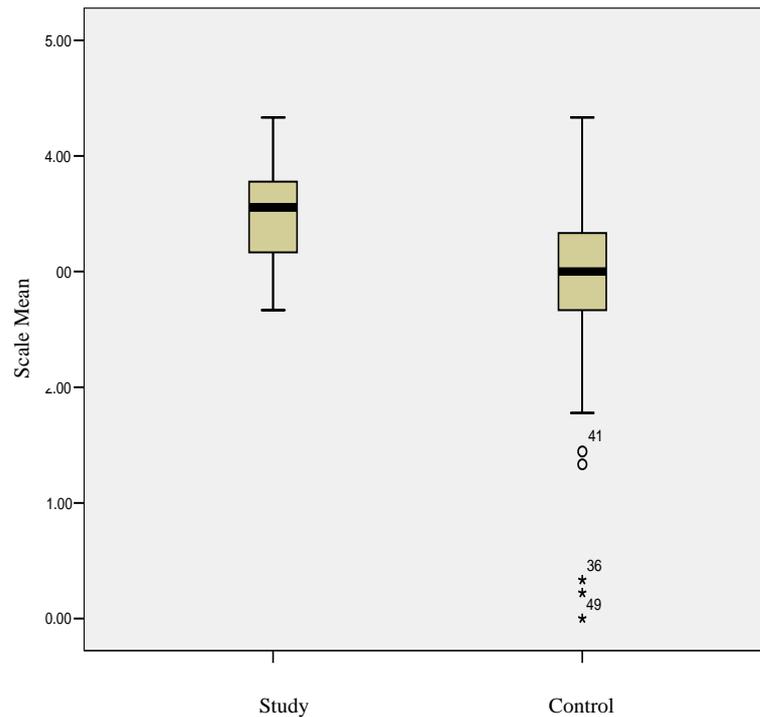
### 6.3.4 Response Scale

The mean scores on the Response scale were 3.52 for the participant group and 2.86 for the control group (see Table 6.6). This means that the participant group on average responded “sometimes” to “often” indicating that the students felt a sense of satisfaction and achievement once they completed the course.

Table 6.6  
*Group Means, Standard Deviations for Response scale*

Group	Response Scale		
	Mean	N	Std Deviation
Study	3.52	11	.52
Control	2.86	38	1.02

The control group were less satisfied, on average they responded “seldom” to “sometimes” indicating they were less likely to feel a sense of achievement and satisfaction on completion of the course. A Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the Response scale. The results of the test for the Response scale were in the expected direction and significant,  $z = -2.126$ ,  $p < .05$ . The study group had an average rank of 33.05, while the control group had an average rank of 22.97. This indicates that the factors identified in the Response scale did contribute to the overall difference in the perceptions of the learning environment, these factors related to the students’ perception of a sense of satisfaction and achievement from their study.



*Figure 6.4.* Comparison of means for Response scale.

Figure 6.4 shows that there was a high level of similarity in the perceptions of the study group members, indicating that members of the study group perceived a sense of satisfaction and achievement in a very similar and positive way. The control group had a slightly greater range of perceptions for this scale than the study group; however, the range for both groups was not as large as has been shown in some of the other scales.

### **6.3.5 Results Scale**

As shown in Table 6.7, the mean scores on the Results scale were 3.78 for the participant group and 3.08 for the control group. The results scale covers information structure and course design activities.

This means that both groups on average responded “often” to “always” indicating that the students agree that the learning objectives and organisation of the web-based learning materials were important in guiding them through their studies. A Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students

who were not included in the study on the Results scale. The results of the test for the Results scale were in the expected direction; however, the difference was not significant,  $z = -1.585, p > .05$ . The study group had an average rank of 31.00, while the control group had an average rank of 23.26.

Table 6.7  
*Group Means, Standard Deviations for Results scale*

Results Scale			
Group	N	Mean	Std Deviation
Study	11	3.78	.54
Control	38	3.08	1.39

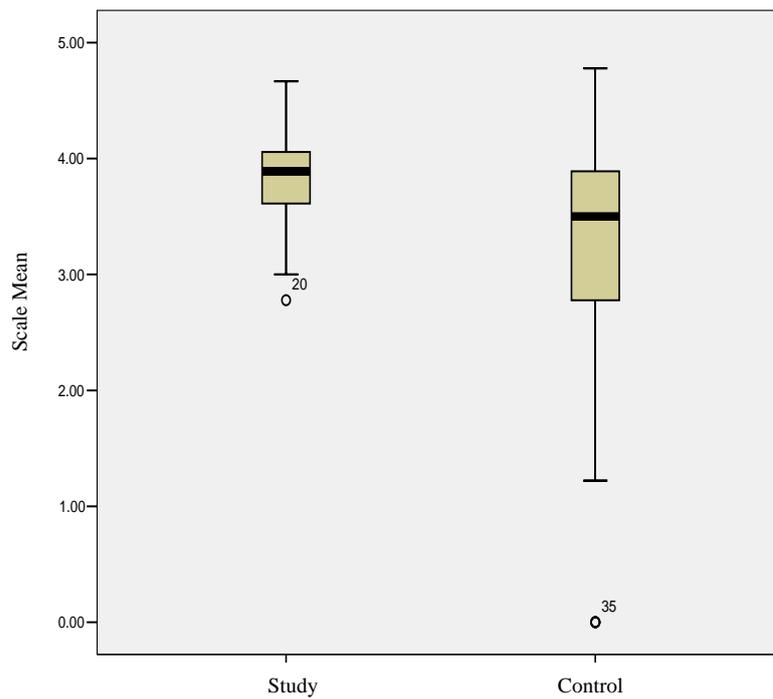


Figure 6.5. Comparison of means for Results scale.

As shown in Figure 6.5, there was a high level of similarity in the perceptions of the study group members, indicating that members of the study group perceived the organisation and design of the course in a very similar and positive way reflecting that they were engaged with the course. The control group had a greater range of perceptions for this scale than the study group, the greater range shown indicates that some of the members of this group perceived lower levels of organisation and course design, this range was greater than the other scales measured with the exception of the Interaction scale.

### **6.3.6 Discussion of Descriptive Statistics and Mann-Whitney *U* tests**

From the descriptive statistics it was apparent that the web-based 3D virtual learning environment trials showed that the environment had potential to provide a rich learning experience for participants and that students perceived this enhanced web-based environment more favourably than students perceived the standard web-based learning environment. This was supported by informal classroom observations, which had indicated that the environment had been enthusiastically received by the students who were involved in the trials.

The WEBLEI was used to provide feedback on one of the intentions of the research, investigating whether the integration of a web-based 3D virtual learning environment into the standard web-based learning environment affected the students perceptions of their learning environment. The indication from the descriptive statistics is that participation in the trial did provide a rich and engaging learning experience that favourably affected these students perceptions of their learning environment.

The Mann-Whitney *U* test examining the *Z*-score and the two-tailed probability-value on the Computer Use scale indicated that the test of difference was not significant. Therefore it was concluded that lack of access to technology was not a factor affecting the difference in overall perceptions of the learning environment between the control group and the study group.

The Mann-Whitney *U* test examining the *Z*-score and the two-tailed probability values on the four scales of the WEBLEI indicated that the difference in means was significant on the Access, Interaction and Response scales. Therefore it

was concluded that the factors identified by the Access, Interaction and Results scales positively affected the study group students' perceptions of the learning environment.

## **6.4 FURTHER ANALYSIS**

The analysis of means and differences between the two groups identified a significant difference between the two groups on the Access, Interaction and Response scales. This indicates that the students in the study group perceived that they had access to the web-based learning materials in a convenient and efficient manner; that they perceived that they could participate and interact regularly with each other and the teacher; and that they perceived a sense of satisfaction and achievement from completing their study.

These analyses were very positive about the use of the web-based 3D learning environment, but did not identify a specific reason why the study group perceived their learning environment as more engaging. Further investigation was needed to gain an understanding of the impact of the 3D web-based virtual learning environment. The data were analysed for correlations between the scales to determine if there were any factors in the scales themselves which explained the reasons for the differences observed.

### **6.4.1 Correlations with year of study**

Simple Pearson correlations were used to investigate associations between the scales of the WEBLEI and year of study, these are reported in Table 6.8. There were two very strong significant correlations between the year of study and the means of data gathered for other scales and demographic data.

The first was a correlation to Computer Use. The Computer Use scale was to identify whether the students had the required access to computers, and the internet, to be able to participate in the web-based learning components of the blended learning environment. The second was a correlation between year of study and the means of the Interaction scale.

Table 6.8  
*Simple Correlations Between Year of Study and Scales in the WEBLEI*

WEBLEI Scale	Simple correlation <i>r</i>
Access	.26
Interaction	.37**
Response	.31*
Results	.28
Computer Use	.42**

N = 49, \* Correlation is significant at the 0.05 level (2-tailed), \*\* Correlation is significant at the 0.01 level (2-tailed).

The use of computers is significantly positively associated with the year of study. As the year of study increases there is a corresponding increase in the number of students reporting more use of computers identified in the items on the Computer Use scale, Figure 6.6 shows items from the Computer Use scale by Year of study each group has its mean rating shown for each category of computer use on the scale.

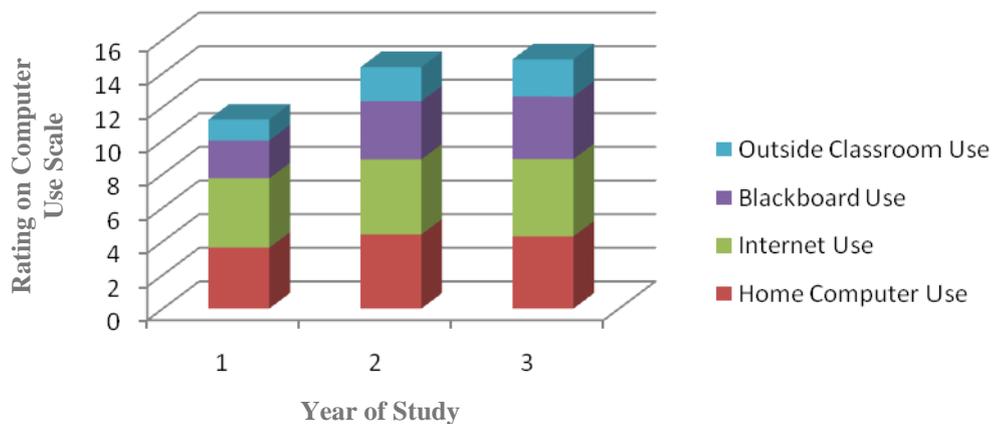


Figure 6.6. Year of study by rating of items on the Computer Use scale.

The greatest increases in rating are in the use of the web-based *Blackboard* resources and computers outside the classroom, with smaller increases in internet use and home computer use. There is also an increase in the overall use of computers between year one and year two students. This is not unexpected, as the students

become more familiar with technology, and gain a better understanding of its role in their learning, we expect them to engage with the technology more.

There is also a very strong correlation between the means on the Interaction scale and the year of study. The Interaction scale measures students' perceptions of the levels of co-participatory activities. Higher scores on this scale indicate that the students perceive they engage in communication and sharing activities with their peers and tutors more frequently. This correlation to year of study indicates, that as the students' progress to the second and third year of the programme there is a corresponding increase in the levels of co-participatory activity.

There are a number of possible explanations for this; the first is that as the students develop trust in their peers and their tutors, they engage more with them. Another possibility is related to the level of group work required in this programme of study. A feature of the Information Technology programmes involved in this research, is the high level of group work expected from students as they progress to higher levels of study. This is to prepare the students to be able to work in teams for the final part of the degree, the capstone project. Furthermore, when they move into the work place they will need to work in teams engaged in software development or Information Technology support.

#### **6.4.2 Simple Correlations between the WEBLEI scales**

As shown in Table 6.9, there are strong significant correlations between the Access and Interaction Scales, between the Interaction and Response scales and between the Results and the Response scales.

These correlations suggest that the scales are somewhat overlapping and that students who perceive that they are in control of their study also interact more with both their peers and their tutors often participating in collaboration in the learning environment. They also perceive that the learning material is well structured and clear, within learning environment, while enjoying the environment, and often experience success and accomplishment in their learning.

Table 6.9  
*Simple Correlations Between the WEBLEI Scales*

	Computer Use	Access	Interaction	Response	Results
Computer Use		.23	.16	.09	.12
Access			.37**	.38**	.44**
Interaction				.64**	.50**
Response					.76**
Results					

N = 49, \* Correlation is significant at the 0.05 level (2-tailed), \*\* Correlation is significant at the 0.01 level (2-tailed).

## 6.5 SUMMARY OF RESULTS OBTAINED WITH THE WEBLEI

The correlations found in the WEBLEI survey data have highlighted two strong positive correlations and one weaker positive correlation with year of study. The scales that show a strong correlation with year of study are the Computer Use and Interaction scales. Higher means on the Computer Use scale have a direct relationship to the students' access to the required technology and the web-based learning environment. Low scores on this scale indicate restricted participation in the web-based learning environment and could inevitably lead to lower scores on all scales of the WEBLEI instrument.

The Mann-Whitney *U* test examining the Z-score and the two-tailed probability values on the four scales of the WEBLEI indicate that the test was significant on the Access, Interaction and Response scales, therefore it was concluded that the factors identified by these scales did result in the study group students' increased positive perceptions of their environment.

This indicates that participation in the trial of the 3D web-based virtual learning environment resulted in an overall improved perception of the learning environment observed for the study group as shown in Table 6.2. However, the significant correlations between the Access scale and the Interaction scale; the Interaction and the Results scales; the Results and the Response scales, indicate that there is no one specific factor influencing these perceptions.

These results have indicated that there was no significant negative difference between the control group and study group, and therefore no ill effect or disadvantage occurred as a result of participation in the trial. These analyses showed enhanced perceptions of the learning environment for the participants in the trial of the 3D web-based virtual learning environment.

## **6.6 RESPONSES TO THE OPEN-ENDED WEBLEI QUESTIONS**

The WEBLEI included four open-ended questions. These questions were optional and asked the students to comment on the following: why they studied in online web-based mode; what advantages there were for this mode of study; what disadvantages there were for this mode of study; and to provide suggestions to improve delivery of courses in an online web-based mode. These responses were coded as: no answer, negative, positive, or neutral. Each answer was allocated one code. They were also coded by the category of the topic addressed in the answer. The categories for the first three questions were information, location, time, communication, money, ease of use, motivation, technology, and collaboration. The categories for the last question, suggestions for improvements were; no change, editing issues, more feedback, more information, more online less in person, more interesting, and technology. If an answer met the criteria for more than one category, the question was coded to all the categories it addressed. The frequencies and distributions of the categories assigned to answers to the open-ended questions were then analysed.

### **6.6.1 Why do you study in online web-based mode?**

When students were asked; “Why do you study in online web-based mode?” Twelve did not answer the question. As shown in Figure 6.7 the responses given were nearly all positive.

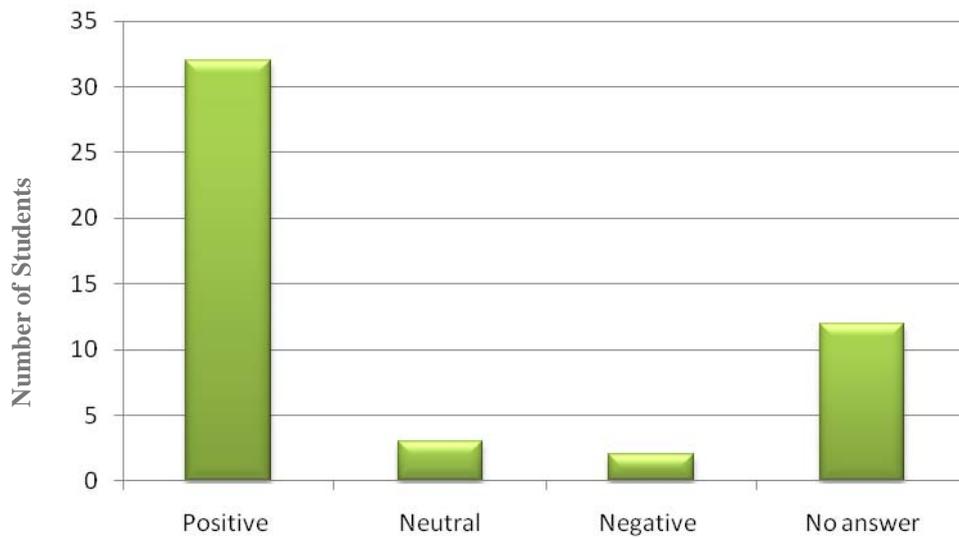


Figure 6.7. Reasons for studying online: percentage of positive neutral and negative answers.

Of the reasons given for studying in the web-based mode: 45.7% identified information; 20% location; 25.7% time as reasons for studying in this mode. A typical answer given was “it has the information I need”. The majority (65%) of the answers supplied were positive. Figure 6.8 shows a breakdown of the reasons given for studying online for the study group and the control group.

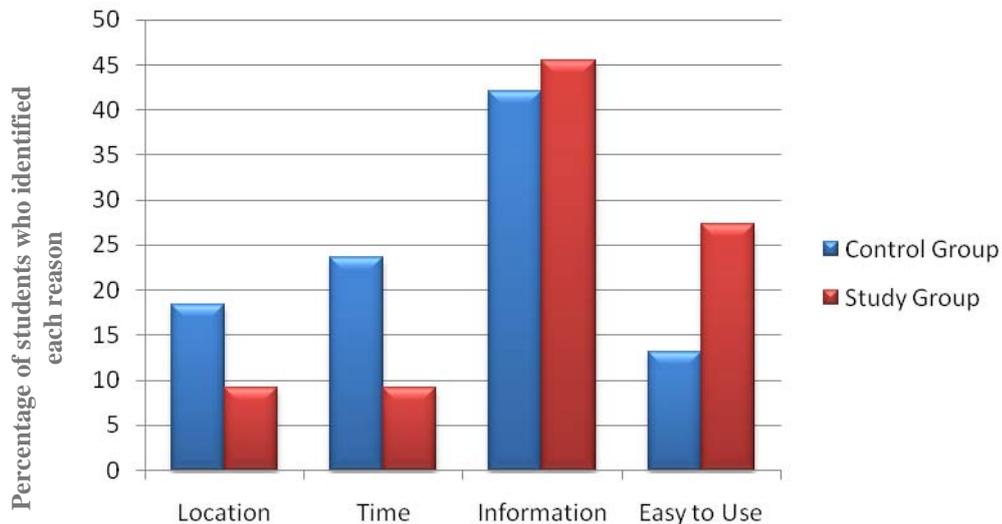


Figure 6.8. Reasons for studying online: percentage of answers by category and group.

Of the students who participated in the 3D virtual world, two did not provide an answer to this question and none identified interaction with students or teachers as

a reason to use the web-based environment. A higher percentage of the study group gave answers mentioning information, and easy to use than did the control group. In fact, the number of study group students identifying easy to use was nearly twice that of the control group.

### 6.6.2 What are the advantages of studying in online web-based mode?

When students were asked, “What are the advantages of studying in an online web-based mode?” Eighteen did not answer the question and all the responses received were positive as was expected by the nature of the question (see Figure 6.9).

Of the answers given to this question: 35.3% identified location; 35.3% time; 20.6% information; and 5.9% communication. A typical answer was “we can do it anywhere anytime” Of the study group, none identified communication as an advantage gained from studying online. Figure 6.10 shows a breakdown of the advantages of studying online, for the study group and the control group.

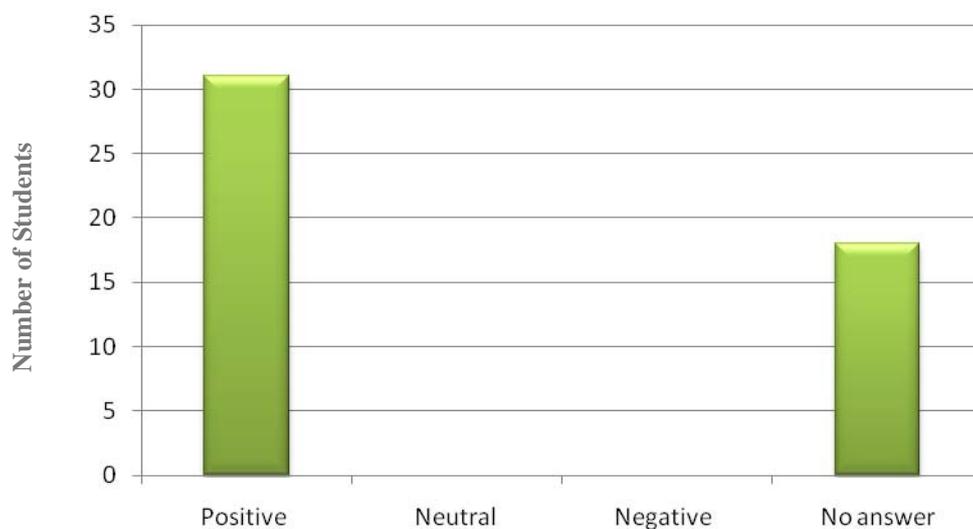
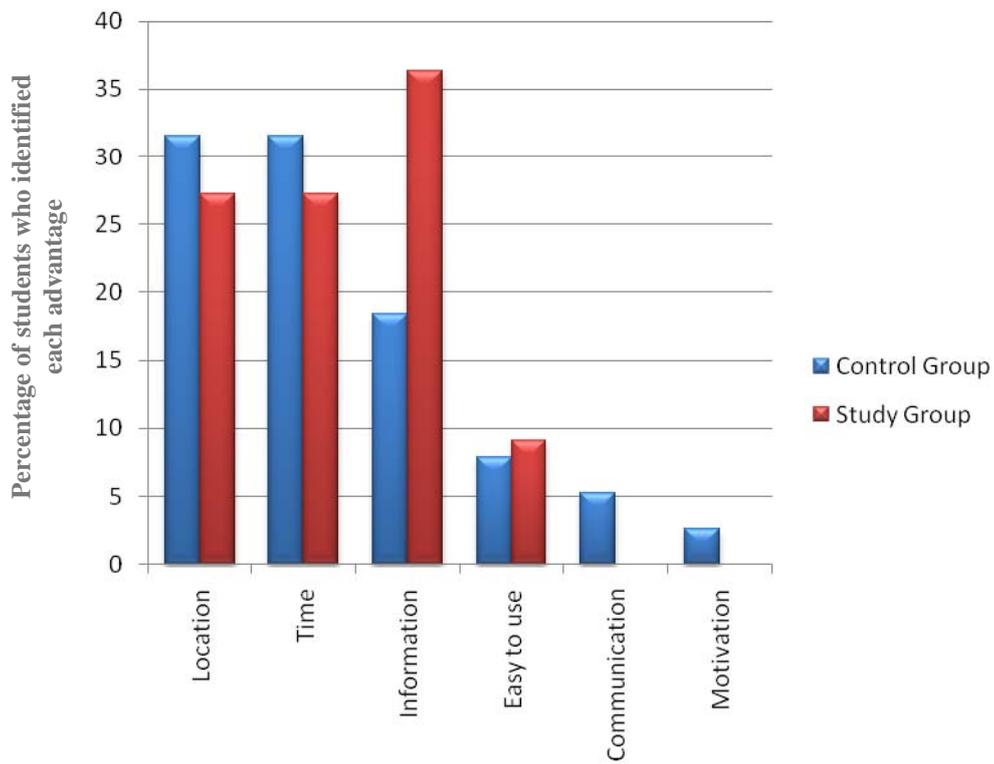


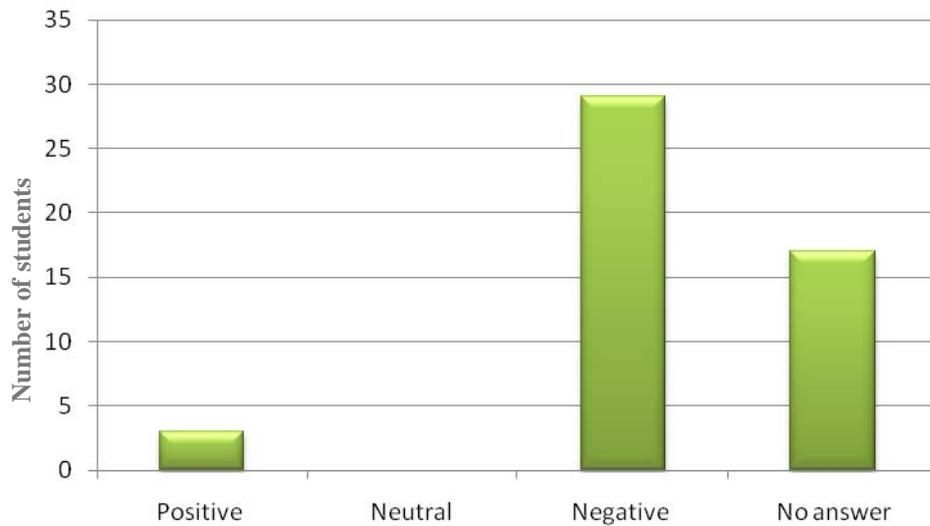
Figure 6.9. Advantages of studying online: number of positive neutral and negative answers.



*Figure 6.10.* Advantages of studying online: percentage of answers by category and group.

### 6.6.3 What are the disadvantages of studying in an online web-based mode?

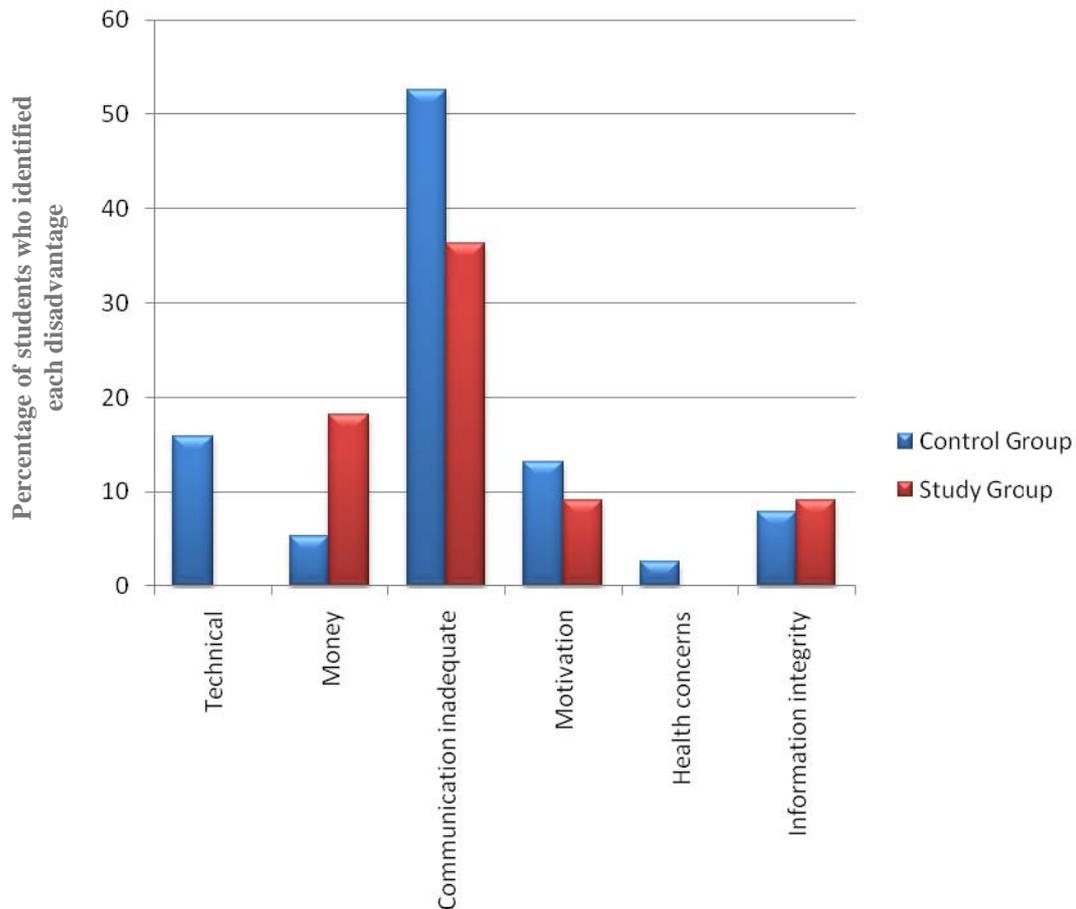
When students were asked “What are the disadvantages of studying in an online web-based mode?” Figure 6.11 shows that seventeen did not answer the question. Of those that did answer nearly all replied with negative answers, as would be expected by the nature of the question, however a few were positive.



*Figure 6.11.* Disadvantages of studying online: number of positive neutral and negative answers.

Of the answers given: 57% identified reasons associated with communication and lack of opportunities to collaborate or get guidance from others. A typical answer was “less interaction feels bored less help”

Of the students who participated in the study, three answered negatively about communication in this mode. The answers were “lack of communication person to person”, “no real-time feedback” and “most students lie on web-based mode”. Figure 6.12 shows a breakdown of the disadvantages of studying online, for the study group and the control group.



*Figure 6.12.* Disadvantages of studying online: percentage of answers by category and group.

#### **6.6.4 Suggestions to improve the delivery of courses online in web-based mode**

When students were asked for suggestions “to improve the delivery of the module in an online web-based mode”, thirty-three did not answer the question. As shown in Figure 6.13, those that did reply were generally critical providing negative answers. These focussed on things that were inadequate or missing in the current environment rather than positive answers, such as liking and wanting more of features already in the environment.

Of the responses given, the most frequent suggestion was to leave things as they are. This was followed by the study group requesting more online delivery, while the control group requested more chat and more interesting content. Other

suggestions from both groups included instruction on use, better quality control on content, to use it more, and to wait for improved technology.

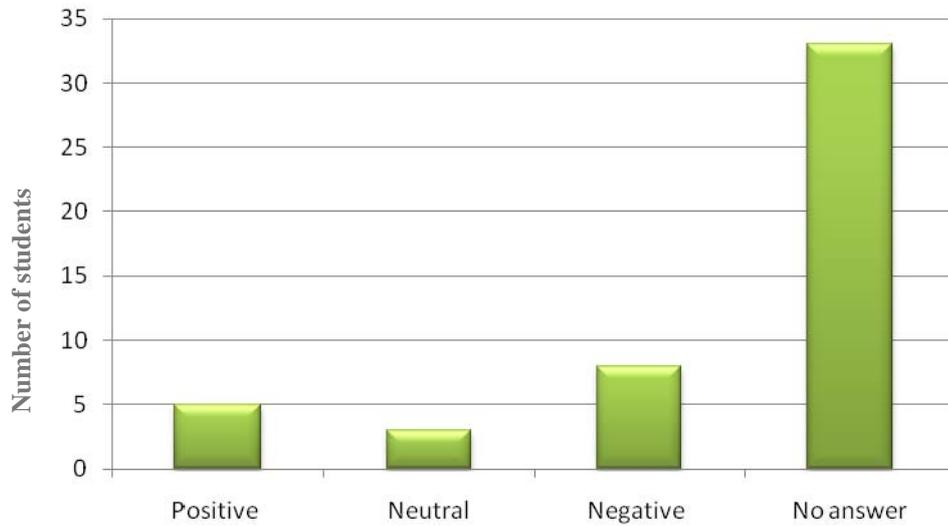


Figure 6.13. Suggestions for improvement: number of positive neutral and negative answers.

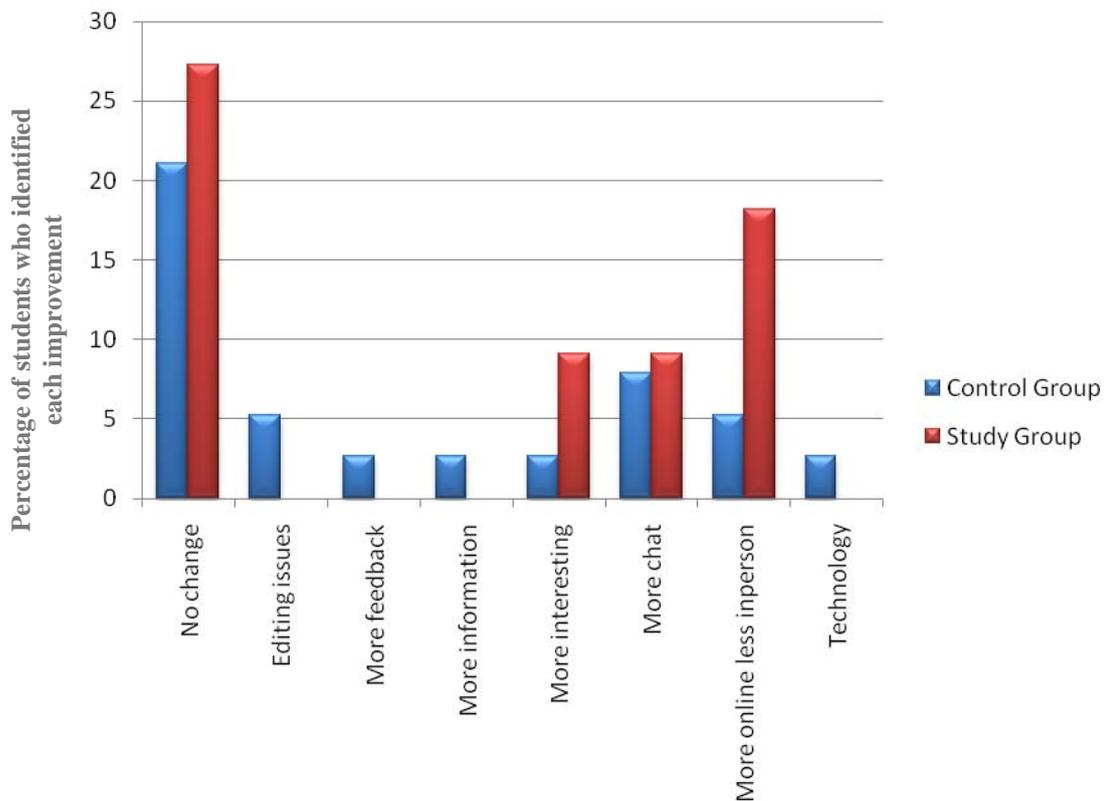


Figure 6.14. Suggestions for improvement: percentage of answers by category and group.

Of the students who participated in the study, five did not answer this question. Of those that did answer the question, the majority gave replies indicating that they did not want changes. Examples of these responses include “no everything is good and fine” and “all is good”. One asked for more online web-based contact and fewer in person sessions, one asked for more chat sessions, and one asked for it to be made more interesting. Figure 6.14 shows a breakdown of the answers by category for both the control and study groups.

### **6.6.5 Summary of the Open-ended WEBLEI Questions**

Coding systems were used to analyse the open-ended WEBLEI question data, identifying all the categories each answer belonged to. Using this system, the open-ended WEBLEI question were analysed to identify patterns. The most frequent reason given by the control group for studying online was access to information, followed by time, and location. There was a difference for the study group whose answers referred to ease of use, ahead of time and location. The most frequent advantage given for studying online was time, followed by location, then information for both groups. The disadvantages identified, varied between the two groups, the study group identified difficulties with communication, followed by cost as the main disadvantages, the control group identified, communication, followed by motivation, then technical issues as the major disadvantages. Suggestions for improvements from both groups had the highest frequency of no answer coded for any of the categories, followed by answers that suggested no change was required to the existing system. The study group then asked for more courses online, followed by more chat. The control group asked for more chat, followed equally by asking for more online courses, and better editing practice.

The major themes running through these answers, were that the participants liked the convenience of working at home at times to suit their other commitments; however, the cost and lack of communications channels was a major disadvantage to this mode of study. It was interesting that both groups would like to see more online courses with more chat facilities, with the study group identifying more courses and the control group identifying more chat as the primary areas for improvement.

## 6.7 USAGE OF THE ONLINE WEB-BASED ENVIRONMENT

The host for the *Adobe Atmosphere* 3D virtual world software was a public web server. This contained the embedded media and an html web page linking to the coordination server software. It was also possible to keep these web-based files locally on a personal computer, or to have a copy on a CD. This is similar to the manner in which online games work. The files that are used to create the “map” or worlds are installed on a local machine, then the software connects to the coordination server to enable the user to compete against other online players.

Some students accessed the worlds using either a CD version of the world, or a version loaded on their own home computer. This meant they were not seeing the current versions available on the website. They did this to avoid large downloads over the internet, and the associated time and costs. However, as there was no file version check built into the coordination server, this did mean that two people who were chatting to each other and appeared to be in the same environment could actually be looking at two different worlds, each with both avatars appearing in them.

The coordination server was hosted on a Linux server running the *Red Hat* operating systems, the coordination server and the text chat software. Third party voice chat servers were used for voice chat. The text chat software running was Yet Another Chat Protocol (YACP) embedded in the *Adobe Atmosphere* coordination server. The coordination and text chat server software were run on a single machine at the polytechnic. This was accessible from the classroom and from the internet. The events for the coordination server software were logged to system logs. For example, if a world had a large number of users, another instance of the world was started automatically, and this event was recorded on the logs. Events such as the server software crashing, or stopping and restarting, also showed on the system logs. The text chat server recorded the messages participants were sending, as it filtered and recorded the messages when it distributed them to the other participants. The filtering feature screened for a banned word list. This meant there was a record of the conversations using the chat feature of *Adobe Atmosphere*.

The text chat logs and logs from the server used to coordinate presence in the worlds, showed that there was minimal use outside organised class activities.

Searching through the logs there were no conversations recorded outside class sessions.

A feature of the Adobe worlds was that a capacity setting determined the maximum number of participants who could join a world. If this capacity was exceeded a new world would be created for the additional participants. The size limit for participants in one world was set at 30 to make sure that performance was fast enough to enable the avatars to move around smoothly. However, during a class exercise this limit proved too low and an additional world was spawned. This meant that there were two subgroups of the class each in different worlds. The members of each subgroup were unable to see or chat to members of the other subgroup. With the exception of this one unplanned incident, the logs only show this event happening again. The only other times additional worlds were spawned was when specific capacity limit testing was being carried out. These tests also showed new worlds being spawned when the connection limit was reached.

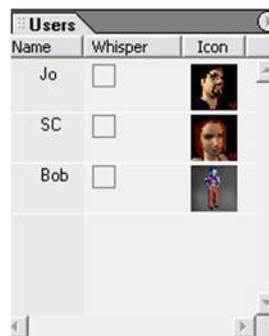
A further indication that the worlds were simply not being used for independent study was an incident that happened during the course in 2005. No one noticed that the chat server was down for two weeks during class time. This happened at a time when the world was opening from a hyperlink on the default home page in the class *Blackboard* site. A car crash took out the power to the area, stopping the server, and it did not restart automatically because of a fault in the hardware. The fact that it was not running was not reported by any student or teaching staff member while it was down. It took over two weeks for a technician to notice the server was not running and restart it.

## **6.8 LIMITATIONS OF THE EVENT RECORDING**

It was possible that the students were visiting the worlds and not engaging in text chat, and this would not have shown up on any of the server logs. It is also possible that they were visiting the worlds and using another internet based chat system such as *Microsoft Messenger* or voice chat servers to communicate with each other. Many of the students were keeping local copies of the worlds on their own machines to avoid repeated downloads of the embedded media. The effect of this was that the web server logs would not necessarily show downloads of the html web

page which included the embedded world from the web server. Loading a local installation of the world did not stop the world connecting to the coordination server, to show the avatars positions and enable chat.

The coordination server was running 24 hours a day meaning no events showing the server starting or stopping would have been recorded when visitors arrived, especially if there was only one person present in the world, as new events would only be triggered if there were more than 30 people present. In addition, if the chat was not used there would be no record of visiting. When a person enters a world, a list of people already in there is visible. Figure 6.15 shows an example of this list in which there are three participants in the world. The list has the participants' nicknames and a picture of the avatar being used. It is possible that on seeing an empty list of users people would not stay logged in to the web-based 3D virtual world.



*Figure 6.15. Chat presence window in Adobe Atmosphere.*

In spite of students indicating that they wanted more synchronous interaction with classmates and teaching staff, it was obvious from the data collected on the servers that the 3D worlds were not being used as a channel for this to occur. The conclusion from the log data has to be that although the students were all observed to participate enthusiastically with set tasks in the web-based 3D virtual learning environment it was not useful to them for studying at other times. The reasons for this evident lack of self-directed use are not apparent from the server log data, nor from the WEBLEI data.

## 6.9 DISCUSSION

The WEBLEI was used to provide feedback on the impact of the web-based 3D virtual learning environment. An initial evaluation of the descriptive statistics from this instrument supported the informal classroom observations, indicating that participation in the trial did provide a rich and engaging learning experience favourably affecting these students' perceptions of their learning environment (Chard, 2005).

Further analysis of the data using Mann-Whitney  $U$  test to examine the hypothesis that the two independent samples came from populations that have the same distributions, discounted the lack of access to technology as a factor affecting the difference in overall perceptions of the learning environment between the control group and the study group. However, the Mann-Whitney  $U$  test examining the  $Z$ -score and the two-tailed probability value on the four scales of the WEBLEI did not identify one particular factor that led to the students in the study group having a more positive perception of their environment than did the control group. Of the four scales, Access, Interaction, Response, and Results; Results was the only scale in which the difference was not significant  $z = -1.585, p > .05$ . The other three scales all showed a significant difference  $p < .05$ , indicating that factors in these scales all contributed to the students in the study group having a more positive overall perception of their learning environment.

Subsequent analysis of the data looking for correlations between the scales showed that the strongest correlations were with the year of study. There were also significant correlations between the Access and Interaction Scales, between the Interaction and Response scales and between the Results and the Response scales. There is no indication from these analyses of the WEBLEI data that the participants in the trial were in anyway disadvantaged, or perceived their learning environment to be any less effective than those who were not involved. However, there is also little indication that can be derived from these results that any specific factor in the web-based 3D virtual learning environment contributed to the enhanced student perceptions of their web-based virtual learning environment.

Analyses of the open-ended WEBLEI question data for themes running through the responses identified that all the students liked the convenience of

working at locations of their own choice, at times to suit their other commitments. However, the cost of technology, cost of internet access, and lack of opportunities to communicate with peers and tutors, was a major disadvantage to this mode of study. Both the study group and the control group would like to see more web-based courses, with more chat facilities included. The study group requested an increase in courses more strongly and the control group requested an increase in chat availability more strongly.

The web server and coordination server data discussed in section 6.7 showed that although all the students were observed to participate enthusiastically with set tasks in the web-based 3D virtual learning environment it was not used for communicating at other times.

These analyses have shown that the students enjoyed using the web-based 3D virtual learning environment, and used it when directed. However, it did not become an integral part of their study practice. The students participating in the trial perceived their learning environment more favourably than the control group, they strongly advocated for it to be expanded to more online courses; however, they still requested additional communications methods including chat, even though there was little evidence to suggest that they were using the chat methods provided.

## **6.10 SUMMARY**

This chapter reported the results of the WEBLEI data analyses and discussed the log data. These analyses indicated that the use of the web-based 3D virtual learning environment, significantly enhanced the perceptions of the learning environment for the participants in the trial but did not identify a particular reason on why the study group perceived their learning environment as more engaging. Further investigation was needed to gain an understanding of the impact of the 3D web-based virtual learning environment. The subsequent research cycles sought further insight through the collection and analyses of additional data which is reported in Chapters Seven, Eight and Nine.

The following chapter, Chapter Seven, introduces the designs created for the web-based 3D virtual learning environments, highlighting the evolution of the designs over time, the general themes, and the metaphors used. It discusses the

design attributes, the nature of the medium, and how to use it effectively as a learning environment.

## **CHAPTER 7**

### **ANALYSIS OF DESIGNS CREATED**

The solutions are all simple... after you've already arrived at them.  
But they're simple only when you already know what they are.  
(Pirsig, 1974, p. 287)

#### **7.1 INTRODUCTION**

This chapter discusses the various designs created throughout the research. These designs include those created by the researcher for the main class world and those created by the students who participated in the study. The design artefacts such as personas, scenarios, features included, and task descriptions are discussed. Examples of the actual worlds created and used are shown. It answers the specific focus research questions nine through eleven identified in Chapter Four, section 4.4.5. These questions are related to the design of future web-based 3D virtual learning environments.

The classes involved in this study used the web-based 3D world technology for course support; in addition, the students created their own designs of environments for purposes related to their coursework for the paper. The main class world was redeveloped annually for four years. Figure 7.1 shows screen captures of the second iteration of the main class worlds. Following a research by design process, designs were created, feedback was gathered and this was used to improve the environment. Feedback came from a number of formal sources, such as the activity observed and recorded in the class world, plus information from the data that were gathered with the expanded WEBLEI. This allowed small changes to be made during the delivery of the course. In addition, as the course ran for one semester a year, major changes were made during the other semester in preparation for each new iteration of the course.

In addition to the analysis of use of the environments discussed in Chapter 6, analyses of the designs produced and the scenarios put forward by the students were conducted. The results from these analyses contribute to an understanding of the

design themes, metaphors, and design issues associated with 3D virtual environments for education, and may be used to inform and provide directions for future research in this area.

Feedback was also gathered from suggestions and requests throughout the research project plus analyses of prototypes and associated documentation created by the students. The final two iterations of this research were design exercises that used a wider range of software, as *Adobe Atmosphere* was becoming difficult to run, these iterations focussed on the design exercises and experimentation with newer 3D world software products.

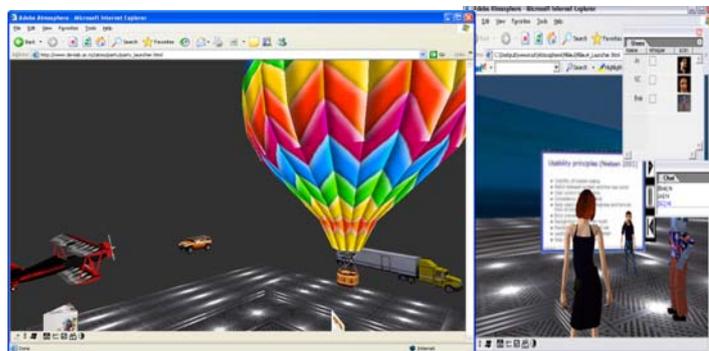


Figure 7.1. Play space and on demand video lecture.

## 7.2 DESIGN REQUIREMENTS FROM THE LITERATURE REVIEW

The creation of a new environment for learning, must consider the theories, models, frameworks, and activities. These provide explanations and models to facilitate an understanding of the environment for learning to take place. These were discussed in Chapter Two. This section discusses the implications for the design of the web-based 3D virtual learning environments.

### 7.2.1 Learning Theory Continuum

The learning theory continuum defined in Chapter Two section 2.2 demonstrated a continuum of theory from behaviourism, through cognitivism, constructivism, and connectivism. This encompasses a broad range of understandings of learning. These theories of learning are not mutually exclusive, and can be supported by overlapping instructional strategies. Learning theory

strategies are concentrated along different points of the continuum, depending on the focus of the learning theory, and the associated level of cognitive processing required.

Learning environments based on behaviourist theories commonly utilize methods that focus on teachers' efforts to transmit knowledge and students' efforts to accumulate knowledge. This is teacher centric and the students are viewed as passive receivers, with a high use of repetition, a technique commonly attributed to behaviourism, to mitigate the forgetting curve. Features to facilitate this transmission model will need to enable learning activities such as lectures and notes to be read, repeated, and remembered. The ability to record and replay lectures support this model. Repetition in forms such as quizzes would also be useful for students learning through these methods.

The methods commonly proposed in learning environments based on cognitivist theory discussed in Chapter Two , section 2.2.2, involve breaking tasks into steps, and delivery of information in small increments, moving from most simple to most complex, linking to the learner's prior experience. Cognitivist theories have an emphasis on students making connections with prior experience, while developing understanding in small incremental steps. This mode of learning involves a task, and small quantities of information readily available to facilitate the next step. This includes discussion, structured tasks, and information. Features to facilitate this mode of learning are chat, preferably audio to enable the discussion to flow easily; and a shared space to work on the task, possibly a shared whiteboard. The features must include sources of information, such as text notes, or short videos. An alternative method could be through a simulation, where the environment is the task, and the information could be embedded in it, as text or videos, to enable the task to be completed. This could take the form of a quiz, treasure hunt, or similar activity.

The methods often associated with constructivist theories lead to learning environments where the teacher's role is seen as a facilitator supporting student learning through mediation, modelling, and coaching. The learning activities are interactive, student-centred, and frequently project-based. To enable a constructivist mode of learning in a 3D environment, the project would need to be embedded in an

environment that includes: access to information; the means of constructing/creating the project; and mechanisms for a teacher to mentor and guide a student. This requires the ability to create objects or projects of some type within the environment, and the means for a teacher to demonstrate the creation to students. Furthermore, students should have the opportunity to show their teacher what they are doing. An example task is for students to be given a project to create their own 3D object or world to be included in the environment. However, for this to be fully integrated as a learning activity the tools to build the 3D object or world would need to be included in the environment.

The role of the educator in a connectivist environment is seen as curatorial, where the educators are expert learners themselves with advanced knowledge of a domain who guide, foster, and encourage learner exploration. Educators create learning spaces/environments in which knowledge can be created, explored, and connected. Learners are autonomous and have freedom to explore in an unbounded environment. The implications for the design of a web-based 3D virtual learning environment to enable this mode of learning are: the environment must be open; and able to be connected to other sources of information, which could be media-based, or to other people. A teacher as a curator would organise the links, search terms and guide the paths that learners are following. The ability to create new knowledge and connections, drawing new external sources into the environment would be paramount to the creation of a connectivist 3D learning environment.

Overall, the designs for the new learning environment must incorporate methods that will enable a balance of strategies for learning to occur throughout this continuum.

### **7.2.2 Social Learning and Interaction Theories**

The group of social learning and interaction theories discussed in Chapter Two section 2.3, highlighted the role of social interaction in learning, implying that learning occurred in all social settings, and that the modelling provided by teachers and other students was a very important part of a learning environment. Social learning theory covers memory, attention, and motivation. It spans behaviourist, cognitivist, and constructivist perspectives on learning. This is a focus on the role of

interaction and community in learning, describing how members both support and challenge each other, leading to effective and relevant knowledge construction. Participants in online communities were described as having a shared sense of belonging, trust, expectation of learning, commitment to participate and contribute.

Interaction in learning environments was defined as occurring between, learners and content, learners and learners, learners and teachers, teachers and teachers, and teachers and content. Each of these interactions has been described as essential for learners to create meaning and understanding.

The implications for a web-based 3D learning environment are that it must support the dialogue between learners, content and teachers. It must also be designed to facilitate these interactions to enable optimal learning to take place.

### **7.2.3 Pedagogy, Andragogy, Heutagogy Continuum**

This research project was conducted in a polytechnic with a very diverse group that had a wide range of needs as learners. A useful framework to guide the design was the understanding of child learning in contrast to adult learning provided through the definitions of the pedagogy, andragogy, heutagogy continuum discussed in Chapter Two section 2.4.

Pedagogy, andragogy, and heutagogy were described as parts of a continuum, with dependent child learners at one end, self-directed adult learners in the middle and self-determined learning at the other end. It was noted that there were times when any of the three approaches might be appropriate based on the circumstances and the needs of the learner.

The discussions on pedagogy identified a teacher-centric view in which the teacher determines what the learner should know and how it should be learnt. The implications for the design of a web-based 3D virtual learning environment are to create an environment where the teacher is in control. This infers that the learning space is focussed on a teacher delivering information and instructions, controlling the interactions and work happening in the learning space.

The five basic concepts of andragogy described in Chapter Two, section 2.4.2 are that adults are self-directed learners who bring a wealth of experience to the educational setting, enter educational settings ready to learn, are problem-centred in their learning, and are best motivated by internal factors.

The implications for the design of a web-based 3D virtual learning environment are to create an environment that supports self-directed learning and cooperative guided interactions between teacher and learner. This would suggest that communication and dialogue are very important in an environment that supports andragogical learners. It also suggests that the tasks allocated must be flexible and negotiable. In addition, lectures should be seminar oriented rather than presentations.

The heutagogical approach recognises the need to be flexible in learning where the teacher provides resources but the learner designs the actual course he or she might take by negotiating the learning. Thus, learners might read around critical issues or questions and determine what is of interest and relevant to them, and then negotiate further reading and assessment tasks. With respect to the latter, assessment becomes more of a learning experience rather than a means to measure attainment.

The implications for the design of a web-based 3D virtual learning environment are to create an environment where the learner is in control. This infers that the primary study space for the learner is their own space or office, where they can accumulate the information resources necessary for their learning. A common space and teacher spaces would also be necessary for discussion and to share work in progress. The ability to create new knowledge and connections and drawing new external sources into the environment are principal features required for the creation of a 3D learning environment that support heutagogical learning.

To provide a compelling web-based 3D virtual learning environment, the designs for the new learning environment must incorporate methods that will enable a balance of strategies for learning to occur throughout this continuum.

#### **7.2.4 Presence**

Presence in virtual environments has been described in Chapter Two section 2.5 as two different concepts, personal presence and co-presence. Personal presence is defined as the perception of being there yourself. Co-presence is defined as the perception that others are there with you. The research referred to in section 2.5 found that there was no statistical difference between an information recall task or a spatial recall task, neither in a real in-person seminar nor in a 3D avatar based virtual conferencing seminar displayed on a desktop. Discussion about the quality of avatars and graphical representations in the 3D environments suggested that higher realism, increased gesture control, and movement methods of avatars, contribute to the sense of realism in web-based online 3D worlds. It also highlighted the importance of view control and avatar animation to support speaker identification, and to provide contextual information. The importance of gestures and visual cues to enable flexible turn taking in virtual environments was also acknowledged.

To develop an environment that is capable of producing the sense of presence described in Chapter Two, the web-based 3D virtual learning environment should include as many sensory channels as possible, have provision of high fidelity graphics, and realistic, animated avatars.

#### **7.2.5 Invisible Student Phenomenon**

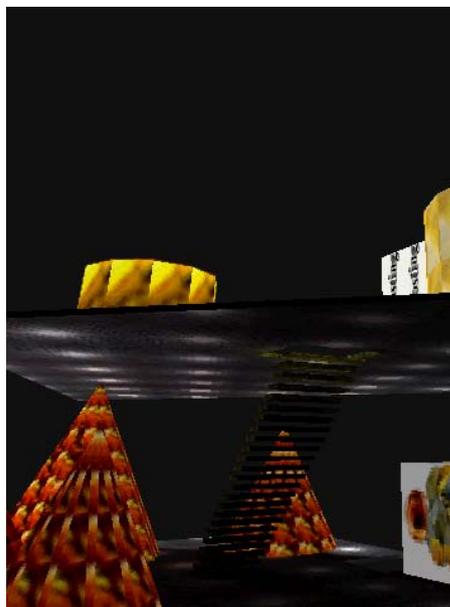
The invisible student phenomenon, often referred to as lurking, was described in Chapter Two as watching without contributing. In a web page-based environment, it is possible to visit web pages without others knowing that you are participating. The web-based 3D virtual learning environment was a synchronous environment in which all participants were visible as avatars to the others present. This meant that it was not possible to remain invisible when visiting the web-based 3D environment.

#### **7.2.6 Summary**

A number of different theoretical perspectives on learning have been described. In the following section, their impact on the designs created by the researcher is discussed.

### 7.3 EVOLUTION OF DESIGNS CREATED BY THE RESEARCHER FOR THE MAIN CLASS WORLD

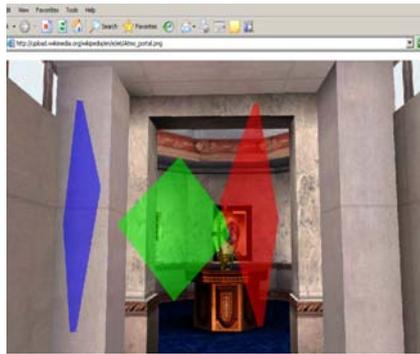
The design of the environments was an iterative process that progressed through four iterations of the main virtual class world. Each iteration involved a class of third year Information Technology students at one New Zealand Polytechnic. The first time the software was utilised was to create experimental prototypes. This process served as an introduction to the tools. These prototypes were designed to provide a chat forum and a space to explore while familiarizing with the software. The early worlds mainly used pictures, sound, and objects within the scenes. Text-based information was limited to signs to convey short notices. The first world created by the researcher was named Crystals and was used to explore the building process, the usability of the software and the methods of embedding media. Figure 7.2 shows a screen capture of this world. This was followed by a capstone project, where a group of students created a world containing music, text, and images, to showcase the Music departments' programmes. This capstone project tested the viability of students, individually or in groups, making their own worlds. It demonstrated that it was feasible for students to create their own designs and build them using the software.



*Figure 7.2. Crystals world.*

The following year the first iteration of the class world was created, all versions of the class worlds contained spaces for large gatherings, a podium, and

methods of displaying visual presentation material to accompany a person presenting an audio lecture. There were teleport links to the student worlds created by the current class group, which were added as the course progressed. A teleport link is shown in Figure 7.3. A separate web page was also available with links to many of the different worlds that were created as part of this research.



*Figure 7.3. Teleport link.*

The implications of the research into presence described in Chapter Two, was that the worlds should engage as many sensory channels as possible, have high fidelity graphics and realistic animated avatars. The software selected for this project was chosen partly because of its high fidelity graphics capability, and the availability of user chosen sophisticated animated avatars.

Students were able to choose their own avatars, and there was a wide range freely available on the web. Some of the avatars were capable of sitting, rolling on the floor laughing, and having a heart attack, they had sound support and realistic movements. Many of the student designs utilised the graphics capability well, this researcher was challenged when creating high quality graphics output and resorted to simple designs or ones readily available for download. The lighting of each world was very important to create the “mood” of the world through generating shadows and colours on otherwise boring backgrounds. However, rendering the lighting could take many hours in a complicated world.

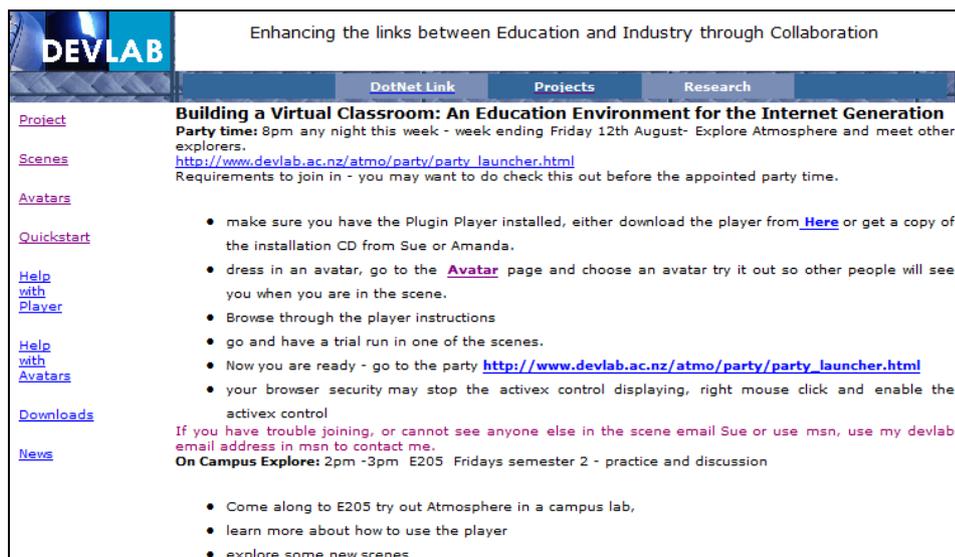


Figure 7.4. Web page with links to class activities.

A feature of the software in use, was that it was not possible to participate without being visible to all the other participants in the world. Even if a student chose a very complicated and slow to load or inaccessible avatar, they were represented in the world by a column of bright colours, which was the default avatar. It was possible to refrain from contributing to the in-world text chat. However, as all the chat appeared in one chat window, when there were more than a few people in the world simultaneously the text chat needed to be passed from participant to participant through a talking stick approach, letting and expecting everyone to have their turn. When the chat was left as a “free for all” the overlapping conversations were very difficult to follow, even though each comment was identified with the participants nickname.

### 7.3.1 First Class World

The first main class world was based on a soapbox metaphor and enabled a large group to observe a speaker and slides displayed on an aerial cube from a surrounding platform. This world was successful, but boring and was not very safe as students could move their avatars to the edge of the main platform then “fall” into a black void.

This world supported behaviourist theories, with a transmission view of learning, however it did not enable repetition. It offered very little support for other

modes of learning on the learning theory continuum. There was an element of constructivist approach in the course design, with the requirement for students to build their own space to be linked into the main class world. However, the building tools were not integrated in the web-based 3D virtual environment, therefore the actual building project, which could be defined as constructivist, was not actually part of the virtual learning environment.

This world supported dialogue between student peers, and between the students and teacher, through the use of synchronous chat in text mode between all participants in the world. The communication between learners and content was restricted to the lecture presentation, which had an audio broadcast with it, but feedback from students was in text-based chat only, also the audio was only available during the lecture time.

This world supported a teacher-centric view of learning with a teacher giving a pre-prepared presentation and answering questions as they arose. From an andragogical perspective, discussion was supported through text chat, however negotiation of goals and flexible elements in the delivery were not incorporated. The addition of the student spaces through teleport links did have the potential to enable some features of a heutagogical learning space; however, the course was not designed to enable the learners to be in control.

### **7.3.2 Second Class World**

The next year the second iteration of the main class world was created. It was safer in that avatars could not accidentally fall. It was an enclosed gallery, with a “screen” that was used to show slides in real-time during lectures or replay the last lecture between classes. The replays of the lectures were not able to be synchronised between the different users in the world as each started independently. The alternative was to have the movie streaming or broadcasting to all users synchronously; however, this would have meant the users had no control over it and would not have been able to stop it or restart it. There was an object in the gallery with a link to *Blackboard* that opened a second browser window with the class Blackboard site. Figure 7.5 shows this world with the cube linking to *Blackboard* in the background. There was another object in the world that played music and a

hyperlinked “play” world with random floating objects to play on. These two worlds are shown in Figure 7.1.

This web-based 3D virtual learning environment only supported the behaviourist view of learning. It did enable repetition of the lecture, and access to more text-based information than was included in the first iteration of the learning environment. The additional world was a small move towards enabling discovery-based learning in a fun environment.

This world was similar to the first main class world created. It continued to support dialogue between student peers, and between the students and teacher, through the use of synchronous chat in text mode between all participants. Communication between learners and content was restricted to text posted as signs in the world and the lecture presentations. This did not enable a two way dialog. Learners could not contribute, and the content was not dynamic. The signs and presentations had audio broadcast with them, but feedback from students was in text-based chat only. The replay lectures were in broadcast mode with no methods of discussion associated with them.

This world was also modelled on a teacher-centric view of learning with both pre-prepared and recorded presentations. From an andragogical perspective, discussion was supported through text chat; negotiation of goals and flexible elements in the delivery were not incorporated. Although the link to *Blackboard* resources did enable a wider range of options, these were outside the main class world. The student spaces accessible through teleport links did have the potential to enable some features of a heutagogical learning space. However, it was still not designed to enable the learners to take control of their learning.



*Figure 7.5.* Link to external data, the white box labelled click me blackboard, in the second iteration of the main class world.

### **7.3.3 Third Class World**

There was a gap in the following year as the researcher was on sick leave and not teaching the class. The third iteration was used in 2007 and this was an expanded world based on a plaza metaphor with the addition of an interactive whiteboard on one side of the plaza plus booths for each lecture. Other booths integrated the text of assignments, class notes, timetables, and links to web-based material. At first, the movies of lectures were set to play when an avatar came into the proximity range of the object displaying the movie. Various means were used to isolate these objects in booths so that a deliberate action was required to get close enough to start the movie playing. However, this was unreliable especially when it came to stopping a particular movie playing, and it was impossible to follow the sound when two or three were playing at the same time. To stop this, scripting was used to provide buttons that had to be clicked to start the movie playing. However, the software was preloading all the items in the world, as a background task so performance was compromised by simply having the possibility of playing the movies included in the world. Overall, this was not a very successful design, as the worlds would not load on computers unless they had good graphics capability and high speed internet connections. This meant it was unable to be used via the internet connections available to most students and they were unable to use this world off campus.

This design was an attempt to expand the previous web-based 3D virtual learning environments to enable active participation in problem solving enabling a cognitive approach using the whiteboard as a shared workspace where ideas discussed could be demonstrated.

As in the previous iterations of the class world, this world supported dialogue between student peers, and between the students and teacher through the use of synchronous chat in text mode between all participants in the world. The whiteboard provided another method of discussion as all participants could write or draw on the whiteboard. Communication between learners and content was restricted. Learners could not contribute to the content and the content was not dynamic. Content was available as text posted on signs in the world and the lecture presentations, these had audio broadcast with them, but feedback from students was in text-based chat only and could not be contributed to the content. The replay lectures were in broadcast mode with no methods of discussion associated with them.

This world was modelled on a learner-centric view giving students accessing to course resources on demand and the learning material being presented through an interactive whiteboard giving more flexibility in tutorials.

From an andragogical perspective, discussion was supported through text chat. However, negotiation and changing of goals was not possible through any means directly incorporated in the world. The student spaces accessible through teleport links did have the potential to enable some features of a heutagogical learning space, although these were not dynamic once created. However, it was still not capable of enabling the learners to take control of their learning and create their own networks for learning. Unfortunately, the technology available at the time did not enable this more flexible approach to perform well enough to support the research objective.

#### **7.3.4 Fourth Class World**

The final class world used was much simpler and had a screen showing the latest lecture. It was embedded in the home page for the class on the *Blackboard* resource pages. It was a simple chat and exploration space embedded in the main

web page for the course material. Figure 7.6 shows an image of the *Blackboard* site with the embedded world.

This design reverted back to the transmission model of learning, leaving out the repetition features provided by the recorded lectures. All the information was provided embedded in *Blackboard* web pages as: text; lecture slides; discussion forums; shared whiteboard and assessments details. The 3D virtual world was available as the body of the main *Blackboard* page for the course, visible to all students as they logged in, as shown in Figure 7.6.

This world also supported dialogue between student peers, and between the students and teacher through the use of synchronous chat in text mode between all participants in the world. The dialogue between learners and content was restricted to the lecture presentation, this had an audio broadcast with it, but feedback from students was in text-based chat only plus the audio was only available during the lecture time.

This world was embedded in the *Blackboard* resources which did enable a more learner-centric view, providing an approach that was closer to the andragogical perspective. The 3D web-based virtual learning environment was still modelled on a teacher centric view with pre-prepared presentations. From an andragogical perspective, discussion was supported through text chat; however, negotiation of goals was not incorporated. This world still had the student spaces accessible through teleport links which did have the potential to enable some features of a heutagogical learning space; however as this was an undergraduate course, it was still not designed to enable the learners to take control of their learning.

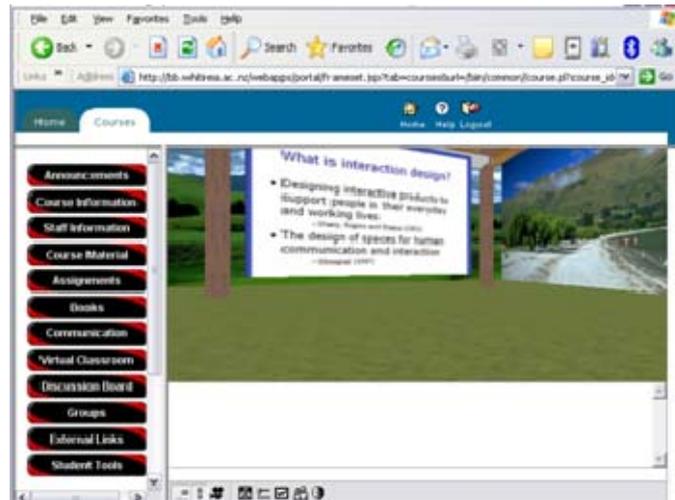


Figure 7.6. Virtual world embedded on main page in *Blackboard* course material.

### 7.3.5 Summary

Redesigning the main class world based on the information gathered through logs and feedback from participants led to the final implementation of the 3D world. This saw the world being used for chat and synchronous presentations while embedded in a *Blackboard* web site. This was the most successful from a technical perspective with few technical issues encountered during this trial. Interestingly, this mirrored the experience of the Hutchworld case study. The Hutchworld study, reported on the development of a community support centre for cancer patients using a similar product, *Microsoft V-Chat*. This used a participatory approach and followed an iterative development methodology (Farnham, et al., 2000; 2002).

In this research, the worlds were initially envisaged as the entire website, with all content information and activity happening in the world. The first three iterations were steps to create this vision. The final world was used to support synchronous chat and an expression of presence using avatars, while the content information was available in the surrounding website with additional asynchronous forums. Furthermore, email-based discussions were provided in the surrounding web pages.

Tiffin and Rajasingham (1995) proposed that education is a communications system where problems, knowledge, learners and teachers are intermeshed, and for learning to take place these components need to operate as a network in a shared

workspace, interacting to solve the problems. In this instance, the problems and knowledge in the form of course resources were available on the *Blackboard* site, the means for learners and teachers to interact to solve these problems were provided by the 3D world. However, there were still significant gaps in the ability to share the work in progress to resolve the problems. Even in the final hybrid environment, the only available means to synchronously share work in progress was a shared whiteboard on which all participants could draw.

#### **7.4 STUDENT DESIGNS**

The first assignment for participating students was to design material for the 3D learning environment. The assignment involved defining personas, task descriptions, usability goals, and user experience goals, followed by designing and developing a prototype world to be published on the web (see Figure 7.7).

These prototypes were published and made available through hyperlinks on a web page, as well as being linked from the main class web-based 3D virtual learning environment using teleport links. An example assignment task is included in Appendix E.

The resulting designs were analysed using nVivo 8 (2009), each was assigned a category according to the design theme used by the student. As reported in Chard (2009, 2010) there were three major categories of designs. First, a small minority of the students created games and simulations, these included activities such as mazes and quizzes. Secondly, the majority created replicas of a physical learning environment, a campus, a classroom, a study space, or computer laboratory in a building. Thirdly, the remainder created galleries, showcasing a topic, such as a country, a specific artist, or musician.

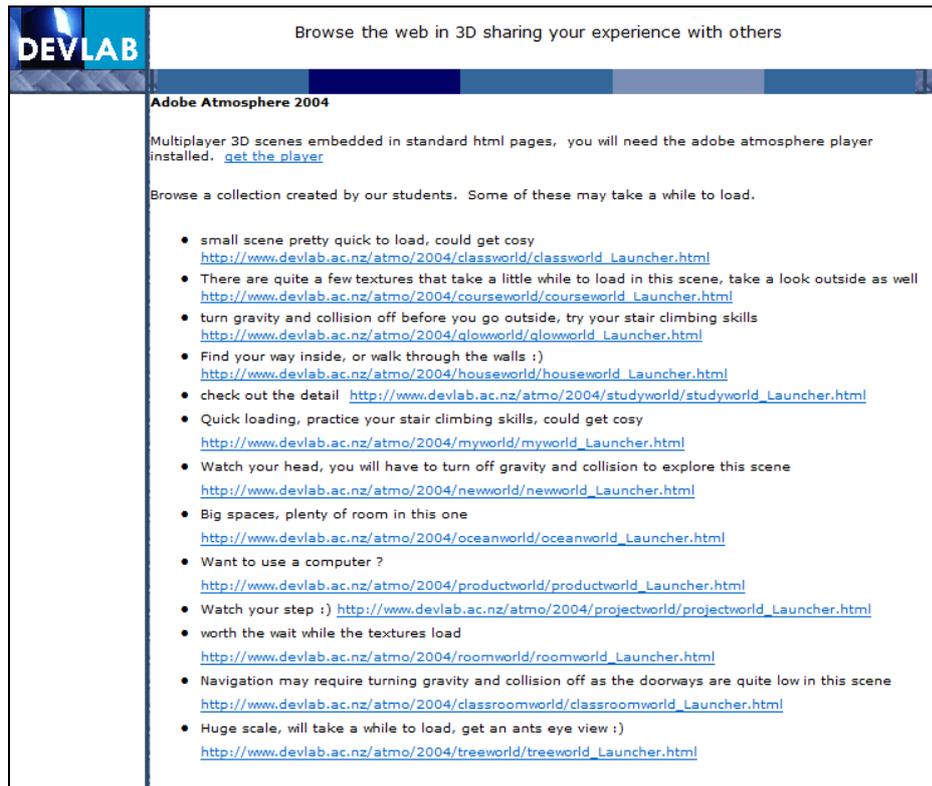


Figure 7.7. Atmosphere 3D worlds created in 2004.

Figure 7.8 shows the proportion of worlds in each category by year. Very few of the designs included learning material, other than pictures, or even references to learning material, only a few had audio components. Figure 7.9 shows a selection of worlds created by students during this research.

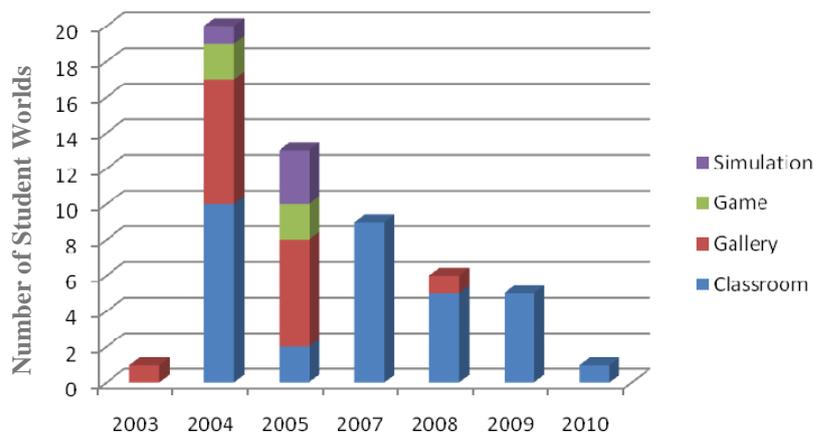


Figure 7.8. Design themes by year.

### 7.4.1 From Galleries to Mazes, From Classrooms to Campuses

The worlds designed by the students are in two groups, group one were created prior to 2006 and group two were created later. The later set of worlds were group projects and in all cases but one these were designs for entire campuses.



Figure 7.9. Examples of student created designs.

These included classrooms, libraries, and other facilities found on a physical campus. The wider scope of these designs reflects the larger groups working together combined, with a greater awareness of 3D virtual environments. These types of environments were becoming more common during this period.

The communications channels built into the worlds always included avatars, images, and text chat as these are in the worlds by default. The early worlds mainly used pictures and objects. Later designs included movies, audio chat, and text-based information such as assignment details and timetables.

#### **7.4.2 Personas Proposed by Students**

The first personas were created by the tutor and closely resembled the students in the classes during 2002 through 2004. The students uniformly identified profiles of students that resembled themselves and their peers. There were only four profiles created of teaching staff and none were created for administrative staff. The inclusion of staff profiles was only observed in the second group of designs from 2007 through 2010. Examples of the way staff featured in the actual worlds included inclusion of tutorial helpdesks and spaces for staff offices (Chard, 2009).

The age ranges of the personas created by students were from 15 years old to 45 years old, 45% were female and 55% male. The mean age was 27 years old, and the most frequent age was 23. This is a very similar mean age to the group that actually participated in the study which was 26.6. However, there was a much higher proportion of female students represented in the personas, as only 22% of the study participants were female. One person identified a persona as multilingual.

#### **7.4.3 Learning Activities and Feature Descriptions**

Task descriptions of learning activities to be supported in the web-based 3D virtual learning environment were created each year by the researcher, as the 3D worlds were designed for each iteration of the research. Also, the students participating in the paper were asked to identify tasks to support learning activities and the features they thought should be incorporated in the environments. They then created their own worlds implementing some of these features, and where practical,

some of the features were then included in future iterations of the main class web-based 3D virtual learning environments.

The first designs were based on tasks initially identified by the researcher in anticipation that these would be the main activities required of the 3D virtual world, they were centred on the teaching activities carried out in traditional classrooms and offices. This list of tasks included: access to course related information such as, assignment tasks, and deadlines; review class notes and attend/replay lectures, discuss/clarify with other students and tutors, arrange meetings; and relieve boredom, stress, and isolation when working outside class times by chatting to other students.

The spaces designed in the first main world, for the use of the students taking the paper, were to facilitate a number of tasks. These included: spaces to attend online lectures with slides and audio; a place for students to look at assessment due dates; the ability for tutors and students to be aware of others who were online and chat with them; and the means for tutors and students to create private places to chat.

In each iteration of the paper, a class exercise was included where students were asked to identify tasks and features they thought should be included in a 3D virtual world for learning. Students who were participating in the paper were asked to list the tasks they expected to take place in the 3D virtual environment and the features that should be incorporated in the web-based 3D virtual learning environments. They were then asked to create designs and prototypes for these worlds.

The tasks identified by students included: attending lectures, attending tutorials, working on assignments, relaxing, discussing with classmates, submitting assessments and accessing grades, co-coordinating with and collaborating with group members, using simulations, participating in online revision quizzes, finding and accessing information, building private and group spaces, and listening to music. There were two categories of tasks that had not been identified by the researcher, these were social activities supporting relaxation and the access to other web-based information resources.

The tasks are reflected in the features the students proposed. There are 33 features identified by the students for inclusion in the 3D virtual worlds. The

students listed on average three features each. This information was used to extend the main class world through the addition of extra features in following iterations of the world. These features are listed in Figure 7.10 in the order of those mentioned least, to those mentioned most frequently.

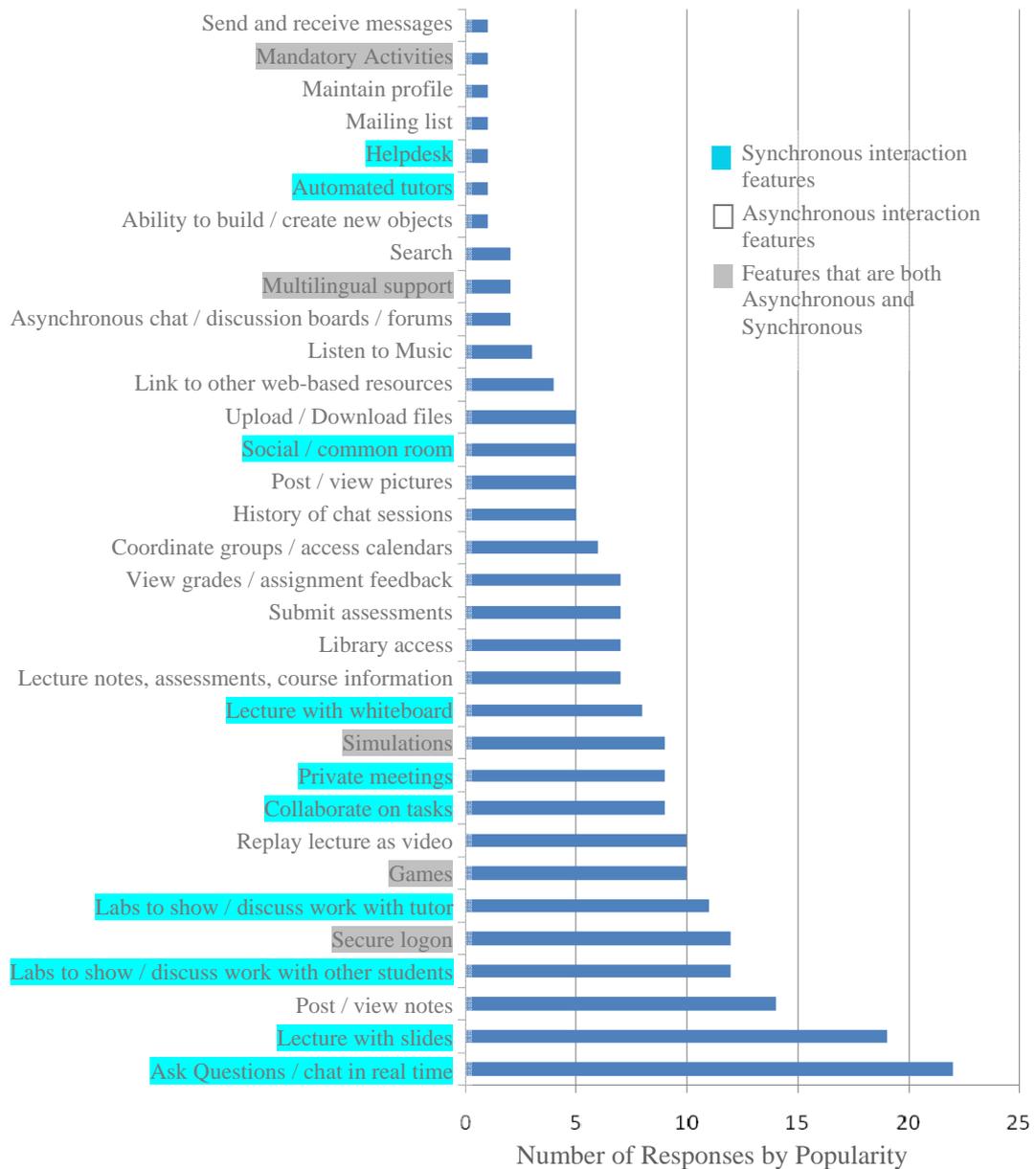


Figure 7.10. Features requested by students in web-based 3D virtual learning environments.

The prototype worlds the students created commonly included a space for conducting lectures, showing either slides with audio support, or pre-recorded videos. Some included noticeboards for text-based information; however, a means of

displaying text-based information was very uncommon, even though it was one of the most frequently identified features required in a 3D world. This was possibly because it was difficult to incorporate static text into the worlds. To do this, the text needed to be created as a graphics image, and applied to a surface as a texture. An example of text included in a world designed by a student is shown in Figure 7.11.



Figure 7.11. Example world with text from two perspectives.

The features identified in Figure 7.10 were also categorised as synchronous and asynchronous. Synchronous features required two or more participants to be online in the same space at the same time. Ten were categorized as synchronous, and 18 as asynchronous, with five identified as both synchronous and asynchronous. However, of the ten most popular features eight synchronous features were listed, while only one was an asynchronous feature.

Table 7.1

*Features not Related to Facilitating Interaction Between Students and Tutors*

Features not related to media	Features related to media
Automated tutors	Listen to Music
Search	Link to other web-based resources
Secure logon	Post / view pictures
	Library access
	Ability to build / create new objects
	Upload / Download files

Of the 33 features identified by students and listed in Figure 7.10, nine were for features not involved in facilitating interaction with either tutors or other students, and of these. As shown in Table 7.1 six of these features related to media such as “listen to music” or “link to other web-based resources”. The other 24 features were for methods to discuss, collaborate, participate, or meet with students or tutors.

Table 7.2 lists the features requested, showing those that were implemented in the different versions of the main class world, and those that were not implemented during this research.

Table 7.2  
*Features Identified During Research*

Features implemented in the 3D virtual worlds used	Features available in the 3D virtual worlds integrated into <i>Blackboard</i>	Features not implemented in this research
Ask questions / chat in real time	Library access	Labs to show/discuss work with other students
Lecture with slides	Submit assessments	Labs to show/discuss work with tutor
Post/view notices	View grades/assignments feedback	Games
Secure logon	Upload / download files	Collaborate on tasks
Replay lecture with video	Asynchronous chat / discussion boards / forums	Private meetings
Lecture notes course information, including assessments	Mailing list	Simulations
Link to other web-based resources		Lecture with whiteboard
Ability to build / create new objects		Coordinate groups / access calendars
		History of chat sessions
		Post/view pictures
		Social /common room
		Listen to music
		Multi lingual support
		Search
		Automated tutors
		Helpdesk

#### 7.4.4 Usability and User Experience Goals

Usability goals were identified by the researcher for the initial worlds designed. The goals identified as most important were “learnability” and “effective”. These usability goals were that the worlds should be able to be used by novices with a minimum of assistance and enable them to accomplish the task they had in mind when arriving at the web page.

In each iteration of the paper being used for this research, there was a class exercise included where students in the study group were asked to identify the usability goals they thought were most important for a web-based 3D virtual learning environment. The number of responses of usability goals identified by students are shown in increasing order in Figure 7.12

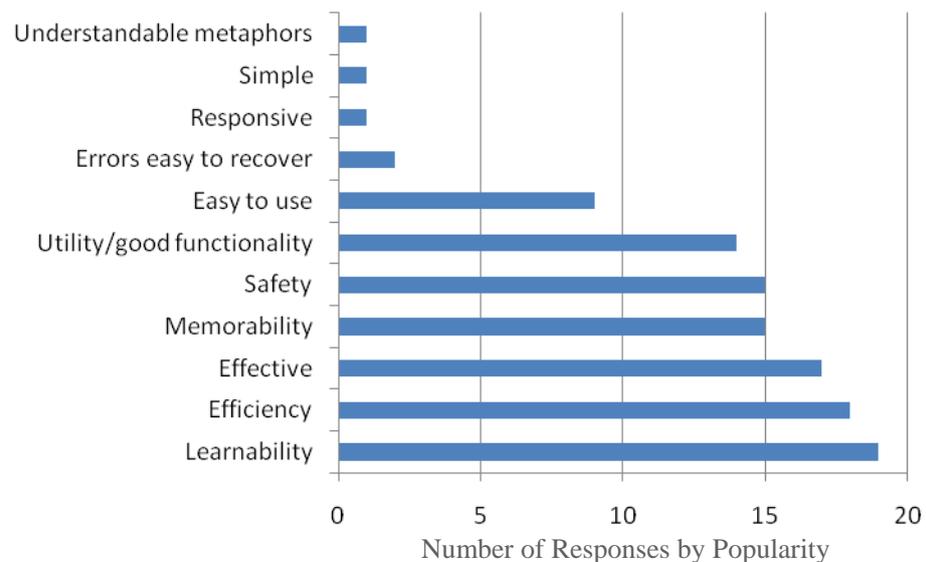


Figure 7.12. Usability goals identified by students.

The usability goals identified by the greatest number of students, as the most important, were “learnability” and “efficiency”, closely followed by “effective”, “memorability”, and “safety”. Most students identified one or two goals. This indicates that the focus for the students was the learning curve associated with a new software environment, and that the ability to accomplish their tasks quickly, without undue interference from the environment was a priority.

The user experience goals identified by the researcher were that the 3D virtual environment should be “engaging” and “motivating”. This meant that using the 3D virtual environment would help engage students in their study, with the result that they would become more engaged in their learning overall.

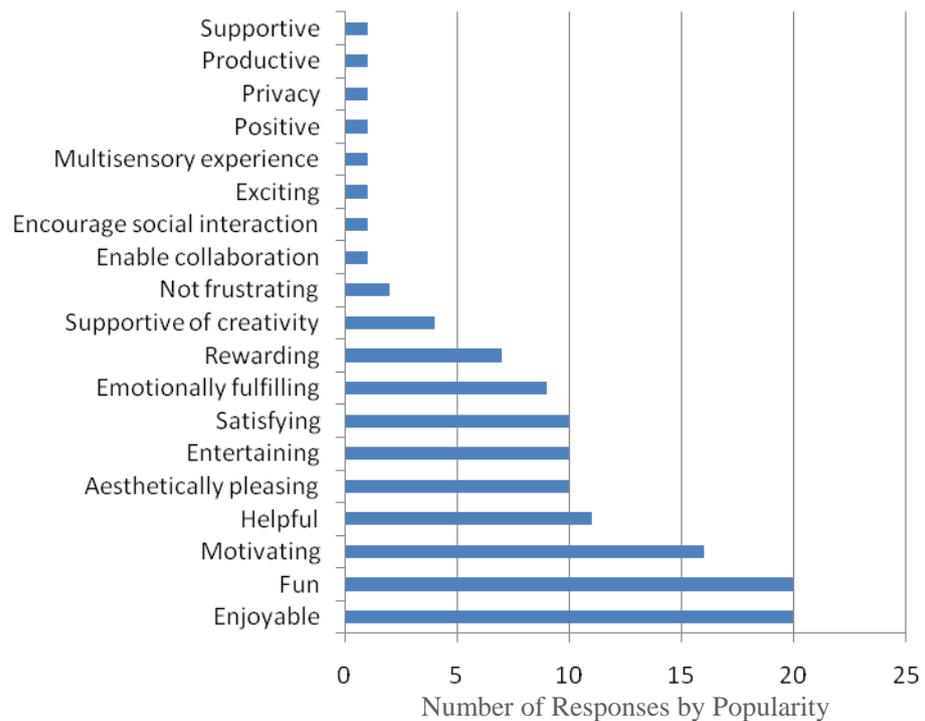


Figure 7.13. Student user experience goals.

In each iteration of the paper being used for this research, there was a class exercise included where students in the study group were asked to identify the user experience goal, or goals, they thought were most important for a web-based 3D virtual learning environment. Students usually chose two goals. A list of these user experience goals identified by the students, in increasing order is shown in Figure 7.13.

The most commonly identified, user experience goals, were “fun” and “enjoyable”, followed by “motivating”. “Engaging” was not mentioned by the students; however, their top choices do indicate that they expected this to be a fun, game-like experience for learners.

## **7.5 SUMMARY**

This chapter discussed the analysis of various design documentation created through seven iterations of the research. These design documents include, those created by the researcher, and those created by the students who participated in the study. The design artefacts such as personas, scenarios, features included, and task descriptions were discussed.

This chapter gave a summary of the design attributes from both the researcher and student perspectives, it highlighted that the designs reflected the technology available at the time. It shows the participatory nature of the research through the influence of the student designs on the evolution of the main class world, and the influence on the researcher's understanding. These included the understanding of the tasks to be carried out and the features that should be included in a web-based 3D learning environment. It also highlights the features identified by the students that were included in the research and those that were not. Chapter Nine synthesises and integrates this analysis of the design data with the other data gathered and analysed during this research.

## CHAPTER 8

### ANALYSIS OF INTERVIEW RESPONSES

We are all interpretive *bricoleurs* stuck in the present working against the past as we move into the future. (Denzin & Lincoln, 2005, p. xv)

#### 8.1 INTRODUCTION

Follow-up interviews were conducted with the students who had participated in the research, after the preliminary analysis of the survey data was completed, and they had completed their study in the programme. The goals of the interviews were to:

- validate findings from WEBLEI;
- answer questions raised by analysing the data collected with the WEBLEI; and
- investigate the potential for further development of web-based 3D virtual learning environments

It was anticipated that the interviews would triangulate the findings in the data analysis from the survey. The survey analysis highlighted the pattern of usage of the web-based 3D virtual learning environment, and identified requests for more availability and use of chat, in addition to the increased interaction channels already available in the 3D worlds. To increase understanding of these factors, the focus of the interviews was on the usage the students had made of the environments, and the technologies actually used for communication.

A second focus was to seek answers to questions raised by the analysis of the WEBLEI data; this was to explore the reasons why the chat environments had not actually been used as a communication method of choice. The aim was also to increase the understanding of the usage of the different media for learning activities

and to gain an understanding of students' perceptions of the potential for these environments.

## **8.2 DESIGN OF INTERVIEWS**

The students were interviewed after they had completed their course of study to avoid any bias in the data. All the interviewees had been awarded their degree prior to the interviews and had graduated, so that none had any compulsion to participate, and the potential bias from the student-teacher relationship was removed. All were informed that participation was voluntary, during the introductory briefing at the start of the interview all were offered the option to opt out. All interviewees were guaranteed that all reporting would be anonymous and that they would be given access to the final written products. At the time of interviewing, all were employed in work that used the Information Technology skills gained from their study at the while studying in their degree programme. Examples of their work are supporting Information Technology networks, end user support of content management systems, developing software, developing websites, and teaching Information Technology courses.

Three of the interviewees had completed further study using online environments after graduating from their course at the polytechnic. Another had had completed an additional postgraduate study in person.

The interviews were semi structured with open-ended questions and additional prompts to elicit responses from participants. Data from the interviews were recorded using handwritten notes. In addition, audio recordings were made of the interviews. The interviews were focused on the following questions:

1. Could you describe your online experience generally: Describe the types of online activities you use?
2. Have you / are you currently using any online study support or studying online?
3. What was your experience of online study at the polytechnic?

4. What sort of communications resources / channels were used for study?
5. Did your online study environment have any ability to chat and include social presence?
6. The 3D worlds, have you used any?
7. How do you think online study could include 3D worlds for learning?

The aim of these questions was for the interviewees to talk about their use of the internet for communicating and learning, focusing on the 3D virtual worlds. The interviews were designed to provide an in-depth perspective on the analyses from the survey, log data, and the web-based 3D learning environments. It was agreed that this would contribute to the development of understanding the phenomena observed in the data. The interviews also triangulated the findings thus increasing the validity and credibility of the research.

### **8.3 PRACTICAL ISSUES**

There were a number of practical issues locating and contacting students, who had either participated in the WEBLEI survey or had been part of the group who used the trial 3D virtual worlds, after they had graduated. A list of students who met the criteria was compiled and current email addresses were gathered from various sources. These sources included: the email addresses provided in the optional question in the WEBLEI survey asking if the respondent was willing to participate in follow up interviews; the *Blackboard* archives, where many students had stored their personal email addresses; and mailing lists associated with technical user groups affiliated with the polytechnic; plus social networking sites.

Thirty-five valid graduate email addresses were identified by these methods from a potential pool of 40 students who had participated in building and using the web-based 3D virtual worlds prior to July 2007. The interviews were conducted from August to November 2007; this was one and a half to two and a half years after the graduates had completed their study. An email was sent out to all these graduates inviting them to participate in an interview, options were given for phone interviews,

online interviews and in-person interviews. Six graduates volunteered to be interviewed, giving a response rate of 15%. There was one female respondent. The respondents covered graduates from four nationalities and the age range at the time of the interviews was from 25 to 41 with a mean age of 31. This method of inviting graduates to participate in the interview process gave a bias towards the more technically engaged graduates and those who had engaged more with their study at the polytechnic. This pool of respondents could be expected to give more positive answers about the use of the technology and its usefulness than the general population. The respondents were all from the group who had participated in the 3D world study, and two had participated in the WEBLEI, student 2 and student 3.

The next issue was arranging times and places to conduct these interviews as the graduates were no longer students at the polytechnic. The interviews were conducted in a coffee shop, workplace meeting room, by phone, and on two polytechnic campuses. The phone and coffee shop interviews posed some issues with recordings as the level of background noise sometimes blocked out the voices on the recordings. In these instances, the handwritten notes were used to augment the audio recordings and assist in understanding the voices in the recordings.

#### **8.4 INTERVIEW QUESTION RESPONSES**

The responses to the interview questions varied considerably, the following summarises the range of responses to the questions. All the interviews strayed off topic, as they were semi-structured interviews, and these questions were used as prompts to refocus the interview.

1. Could you describe your online experience generally: Describe the types of online activities you use?

The most frequent answer was email. Other items mentioned were online auctions, finding information, podcasts.

2. Have you / are you currently using any online study support or studying online?

All had used online study at polytechnic and three had completed further online study in a formal setting for industry certifications and other tertiary qualifications.

3. What was your experience of online study at the polytechnic?

Experience was limited to *Blackboard* and the *Adobe Atmosphere 3D* virtual world; various descriptions were given of these products.

4. What sort of communications resources / channels were used for study?

The answers included email, forum, chat, MSN and shared group workspaces available on *Blackboard*.

5. Did your online study environment have any ability to chat and include social presence? Did you use it, was it useful, what sort of activities? Who did / would you use it to communicate with?

The answer was universally “Yes” and it was used for the coordination of group work, sharing project work and notes. It was used to communicate with other class members or group project participants.

## **8.5 THE INTERVIEW DATA THEMES**

Analysis of the interview data was conducted using nVivo 8 (2009) from the transcripts, the recordings, and the hand-written notes. The data were initially analysed to identify common themes arising in the interviews using keyword searches. A number of themes were identified in the interviews. Two in particular ran through all the interviews and these were; the use of the mobile phone Short Messaging Service (SMS) text messages to coordinate groups to meet at the same time and place; and the time wasting properties of software designed to facilitate social interaction, such as chat programs and multiplayer games. Other weaker themes centred on the inadequacy of the current technology; including internet access; and the usefulness, or otherwise, of forums and email.

Working together and the coordination methods used to enable the groups to be in the same place at the same time were repeatedly mentioned in all the interviews. Examples include:

*we would txt conversation to fix a time and location* Student 1

*group work together in person – txt to organise* Student 2

*txt to organise groups working together* Student 3

*msn chat to decide if to phone* Student 4

*used email txting just meeting up with people* Student 3

The purpose of these meetings became apparent when, the interviewees talked about, the peer support that carried them through their study and helped them successfully complete the programme.

*if it wasn't for the people - I wouldn't have got through* Student 3

*get help from friends* Student 5

*MSN at three in the morning with [another student] to finish an assignment*  
Student 3

The other theme that was raised in all the interviews was the time wasting factor and distraction introduced by the use of chat and multiplayer games. Example comments were:

*people get addicted to it takes too much time* Student 1

*conversation carries on too much* Student 1

*talking some rubbish for five hours conversation becomes meaningless*  
Student 1

*chat is a timewaster, once started its hard to stop* Student 2

*Games are a timewaster* Student 2

*3D is a distraction”* Student 3

*Online games are time wasters* Student 3

*doesn't stop talking for ages when you start talking too* Student 4

*obsessive* Student 5

This is a new theme as issues around the time wasting aspects of the technologies designed for social interaction, such as chat and avatar-based environments, were not mentioned in the WEBLEI open-ended questions and were not addressed in the WEBLEI scales. The most relevant questions in the WEBLEI scales are the questions about the self-discipline required to study in online mode, this could be interpreted as self discipline to avoid being distracted by other online activities.

The use of forums was brought up a number of times; however, interviewees experience of the use of forums for study varied considerably. Four of the interviewees identified that they had limited experience of forums as an integral part of a learning environment, with only one or two papers including forums; two other interviewees reported that they did have extensive experience in the use of forums for study. From the comments expressed there appeared to be two approaches to forums. First: forums were another type of assessment that students had to provide submissions or posts for but were not used otherwise. Secondly, forums were a place you went to look for answers, but did not contribute questions. The comments included:

*used [a] forum a few times but didn't check answers Student 1*

*look at what's in the forum for the answer Student 5*

Forums were not specifically mentioned in the open-ended question data from the WEBLEI. The question that is most likely to have registered use of forums in the WEBLEI asks about asynchronous interaction. This question is Question 28 which asked the students to rate the following statement “This method of learning enables me to interact with other students and the tutor asynchronously,” in relation to their online environment. It showed a mean of 2.97 for the study group and a mean of 2.14 for the control group. A score of 3 is a rating of sometimes and 2 is seldom indicating that the students who completed the WEBLEI did not use the forums provided as an integral part of their study process.

Another area that concerned the graduates interviewed was the inadequacy of technology, principally the speed of the internet and the availability to all students caused concern. There was discussion about the use of rich media and video at home, one commented that, with their current access to the internet, it was possible to watch video at work, but they could not at home. Some examples of the comments:

*learn online from text and podcasts ... internet too slow at home Student 5*

*technology wasn't as good Student 3 referring to technology at the time they were studying.*

The inadequacy of the technology was also a frequent theme in the WEBLEI open ended question responses. Comments from the control group included:

*computer crashes a lot which puts a delay on studying*

*need to get online*

Comments from the study group centred around the cost of the technology, including:

*ISP Costs*

*cant afford internet connection*

The respondents varied in their perceptions of the usefulness of email and chat, with some preferring email and finding that people responded in a useful timeframe, others preferring chat as email was too slow. The most favourable opinion of chat came from a graduate working as a software developer in a web development company that used chat continuously as a coordination mechanism for the developers, even though they were all seated in the same room within sight of each other.

## **8.6 RELATIONSHIP TO RESPONSES ON WEBLEI**

Analyses of the interview data identified two major themes and three minor themes in the data. The major themes were the use of SMS messages to coordinate groups to meet at the same time and place, plus the time wasting properties of social presence such as chat programs and multiplayer games. Other minor themes identified in the interview data were the inadequacy of the current technology including internet access, plus the usefulness of forums and email.

The responses to the open-ended questions on the WEBLEI survey were analysed to see if these showed any similarity to the themes identified in the interview data. Two strong themes were apparent in the WEBLEI open-ended question response data, but they did not match the strongest themes, of SMS use and the time wasting caused by social presence, that had been identified in the interview data. The items in the WEBLEI that were related to interaction including the use of forums, groups, and chat as identified in the interviews, were also analysed for similarities in responses.

### **8.6.1 Relationship to WEBLEI Open-ended Question Response Data**

Analysis of the WEBLEI open-ended questions for the study group identified two strong themes. First, the inadequacy of the technology, including the lack of

usable internet access, was identified strongly and was one of the themes in the interview data. However, the second strong theme was the request for more direct and synchronous feedback using chat. Interestingly, this was not identified as an issue in the interview data.

Additional themes identified in the interview data, not reflected in the WEBLEI, related to SMS messages for group coordination, time wasting caused by social presence, use of forums, and a preference for email-based communication open-ended response data.

### **8.6.2 Relationship to WEBLEI Items on the Interaction scale**

The items in the WEBLEI scales that related to the areas highlighted by the interview data asked about the students' participation in web-based communication activities. These were the items in the Interaction scale, questions 16 to 26. The response criterion for these questions was: 5-“always”; 4-“often”; 3-“sometimes”; 2-“seldom”; 1-“never”. The preferred methods of communicating using SMS text messaging and phone calls, identified in the interviews, were not represented in the WEBLEI scales as they were specifically focused on web-based communications available in the learning environment.

The responses to the individual questions 16 to 26 in the WEBLEI scales, were analysed to identify any significant differences between the responses from the control group and the group who participated in the study. A Mann-Whitney *U* test was conducted to evaluate the hypothesis that the students who participated in the trial would score higher on these items, on the average, than the students who were not included in the study. These were then compared to the response data from the interviews. Table 8.1 shows the means and standard deviations for the responses to this group of items by study and control group.

Table 8.1  
*Means and Standard Deviations of WEBLEI Items for Study Group and Control Group*

	Control Study	Mean	Std. Deviation
16. I communicate with other students in my classes by email.	C	2.45	1.25
	S	3.55	1.13
17. I communicate with other students in my classes through a discussion board.	C	1.61	.79
	S	2.64	1.29
18. I communicate with other students in my classes electronically using chat.	C	2.24	1.34
	S	2.45	1.29
19. I communicate with other students in my classes electronically using a electronic whiteboard.	C	1.39	.95
	S	1.82	1.33
20. I communicate with other students in my classes electronically using a group workspace.	C	1.55	1.01
	S	1.64	1.03
21. I have to be self disciplined in order to learn in this online environment.	C	2.92	1.51
	S	3.45	1.13
22. I use electronic methods to ask my tutor for help when I do not understand.	C	2.61	1.33
	S	2.55	1.21
23. I use electronic methods to ask other students for help when I do not understand.	C	2.21	1.30
	S	2.09	1.51
24. Other students respond promptly to my queries electronically.	C	1.82	1.41
	S	3.00	1.34
25. The tutor responds promptly to my queries electronically.	C	2.92	1.63
	S	3.18	1.40
26. I participate in online tasks.	C	2.53	1.41
	S	3.64	1.29
27. I am support by positive attitudes from my peers.	C	3.29	1.54
	S	3.73	.65

Control Group  $n = 38$ , Study Group  $n = 11$

### ***8.6.2.1 Interaction scale questions with no significant difference between the control group and the study group related to the interview data***

Using a Mann-Whitney  $U$  test, the following Interaction scale items all showed that there was no significant difference between the control group and the study group.

The mean of the responses by the study group to question 18, “I communicate with other students in my classes electronically using chat”, was 2.45-“seldom”. This also reflects the graduates’ comments in the interviews as they did mention using chat to talk to other students when working on assignments at home, but did not indicate that they used it more frequently or in preference to other methods of communication. The control group mean for this question was 2.24. A Mann-Whitney  $U$  test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the items in the Interaction scale. The results of the test for question 18 were in the expected direction; however, the difference was not significant,  $z = -.561$   $p > .05$ . The study group had an average rank of 27.05, while the control group had an average rank of 24.41.

The mean of the responses by the study group to question 19, “I communicate with other students in my classes electronically using an electronic whiteboard”, was 1.82-“seldom” and this means of communication was not mentioned in the interviews. The control group mean for this question was 1.39. The Mann-Whitney  $U$  test for question 19 were in the expected direction; however, the difference was not significant,  $z = -1.145$   $p > .05$ . The study group had an average rank of 28.27, while the control group had an average rank of 24.05.

The mean of the responses by the study group to question 20, “I communicate with other students in my classes electronically using group workspace”, was 1.64-“seldom”. The use of a shared group workspace was discussed by three of the graduates interviewed in relation to their work on the final capstone project for the degree. The surveys were completed prior to the start of this project. The capstone project requires groups of two to four students, usually groups of three, to work on a project for an external client. This project is a double credit paper and a substantial piece of work that requires the group to work closely together and communicate with

the client to be able to produce the required outcome for the project. The experience of working on this project would have affected the students' need to share work, and would reasonably be expected to increase their use of group workspace. This project experience was after the WEBLEI data were collected, and before the interview data were collected. The control group mean for this question was 1.55. The results of the Mann-Whitney  $U$  test for question 20 were in the expected direction; however, the difference was not significant,  $z = -.265$   $p > .05$ . The study group had an average rank of 25.86, while the control group had an average rank of 24.75.

The mean of the responses by the study group to question 21, "I have to be self disciplined in order to learn in this online environment", was 3.45-"sometimes". The control group mean for this question was 2.92. The results of the Mann-Whitney  $U$  test for question 21 were in the expected direction; however, the difference was not significant,  $z = -.914$   $p > .05$ . The study group had an average rank of 28.36, while the control group had an average rank of 24.03. This rating 3.45 is the second highest in this group of questions, and is also the second highest in the control group. This is possibly reflected in the interview comments about the time wasting and the distractions introduced by social presence and chatting when studying using the online environment.

The mean of the responses by the study group to question 22, "I use electronic methods to ask my tutor for help when I do not understand", was 2.55-"sometimes". The control group mean for this question was 2.61. The results of the Mann-Whitney  $U$  test for question 22 were in the expected direction; however, the difference was not significant,  $z = -.012$   $p > .05$ . The study group had an average rank of 25.05, while the control group had an average rank of 24.99.

The mean of the responses by the study group to question 23, "I use electronic methods to ask other students for help when I do not understand", was 2.09-"seldom". The control group mean for this question was 2.21. The results of the Mann-Whitney  $U$  test for question 23 were in the expected direction; however, the difference was not significant,  $z = -.315$   $p > .05$ . The study group had an average rank of 23.86, while the control group had an average rank of 25.33.

The mean of the responses by the study group to question 25, “The tutor responds promptly to my queries electronically”, was 3.18-“sometimes”. The control group mean for this question was 2.92. The results of the Mann-Whitney *U* test for question 25 were in the expected direction; however, the difference was not significant,  $z = -.344$   $p > .05$ . The study group had an average rank of 26.27, while the control group had an average rank of 24.63.

The mean of the responses by the study group to question 27, “I am supported by positive attitudes from my peers”, was 3.73-“often”. The control group mean for this question was 3.29. The results of the Mann-Whitney *U* test for question 27 were in the expected direction; however, the difference was not significant,  $z = -.520$   $p > .05$ . The study group had an average rank of 26.91, while the control group had an average rank of 24.45.

From these analyses of the WEBLEI Interaction scale items, two have been identified as supporting the interview data, while one item was shown to contradict interview data.

Question 18, about the use of chat to talk to other students, data showed no significant difference between the study group and the control groups. This finding is supported by the interview data, which did not support the premise that the study group used chat as a frequent means to contact other students.

Question 21, about the self-discipline necessary to study in the web-based environment, showed a high rating by both the study group and control group and supporting evidence is provided in the analyses of the interview data, with the comments about the distractions of social presence and time wasting caused by the use of chat programs.

Question 20, about the use of shared online workspace for group work, analyses of this item data showed a low usage by the study group and the control group, while the interview data indicated that the interview group had made extensive use of this shared workspace and found it very useful. The timing of the survey and interviews account for this anomaly as the survey was conducted before any of the interview participants had commenced work on the final part of the degree programme. The final part of this programme is a significant capstone group project.

The interviews were conducted after this project experience, which would have necessitated extensive use of the workspace.

#### ***8.6.2.2 Interaction scale questions with a significant difference between the control and study groups related to the interview data***

Table 8.1 shows the means and standard deviations for the items on the Interaction scale. There was a significant difference between the control group and the study group for items 16, 17, 24 and 26. The following discussion investigates these differences between the control group and the study group, comparing the WEBLEI data with the interview response data.

The mean of the responses by the study group to question 16, “I communicate with other students in my classes by email”, was 3.55- often”. This does reflect the interview responses that indicated the preferred method of web-based communication was email. The control group mean for this question was 2.45. A Mann-Whitney  $U$  test was conducted to evaluate the hypothesis that the students who participated in the study would score higher, on the average, than the students who were not included in the study on the items in the Interaction scale. The results of the test for question 16 were in the expected direction and significant,  $z = -1.980$ ,  $p < .05$ . The study group had an average rank of 34.36, while the control group had an average rank of 22.29. This indicates that the study group of students were more likely than the control group to use email to communicate with other students. This difference is possibly because the study group were all year three students while the control group was predominantly year one and two students as section 6.4.1 showed a very strong correlation between the means on the Interaction scale and the students’ year of study.

The mean of the responses by the study group to question 17, “I communicate with other students in my classes through a discussion board”, was 2.64-“sometimes”. This also reflects the comments about forums in the interviews, as some of the graduates interviewed reported that they did not participate in forums, they either passively consumed the information already posted, or posted to the forum as part of a compulsory assessment activity, and did not look at the responses. The control group mean for this question was 1.61. The results of the Mann-Whitney  $U$  test for question 17 were in the expected direction and significant,  $z = -$

2.542,  $p < .05$ . The study group had an average rank of 34.05, while the control group had an average rank of 22.38. This indicates that the control group was even less likely to engage with forums. This difference is possibly because the study group were all year three students while the control group was predominantly year one and year two students as section 6.4.1 showed a very strong correlation between the means on the Interaction scale and the students' year of study. This result does raise questions regarding the effectiveness of forums and discussion boards within learning environments that should be investigated further.

The mean of the responses by the study group to question 24, "Other students respond promptly to my queries electronically", was 3.00-"sometimes". The control group mean for this question was 1.82. The results of the Mann-Whitney  $U$  test for question 24 were in the expected direction and significant,  $z = -2.400$ ,  $p < .05$ . The study group had an average rank of 33.82, while the control group had an average rank of 22.45. This indicates that members of the study group were more likely to respond quickly to emails than the control group. This difference is possibly because the study group were all year three students while the control group was predominantly year one and year two students, as section 6.4.1 showed a very strong correlation between the means on the Interaction scale and the students' year of study. However, it does reflect the preference for email communication voiced in the interviews.

The mean of the responses by the study group to question 26, "I participate in online tasks", was 3.64-"often". The control group mean for this question was 2.53. The results of the Mann-Whitney  $U$  test for question 26 were in the expected direction and significant,  $z = -2.307$ ,  $p < .05$ . The study group had an average rank of 33.55, while the control group had an average rank of 22.53. This indicates that the control group was even less likely to engage with online activities. Again, this difference is possibly because the study group were all year three students while the control group was predominantly year one and year two students as section 6.4.1 showed a very strong correlation between the means on the Interaction scale and the students' year of study.

These four questions included communicating with other students via email, and receiving prompt responses to email from other students. This is supported by

the interview comments related to email being an effective and fast way to collaborate with other students.

The other two questions were about participation in online tasks and discussion boards, even though these two questions were answered in a significantly more positive way by the study group of students than the control group, the means were both lower than expected. The mean for the use of discussion boards was 2.64-“sometimes”, and the mean for the control group was 1.83-“seldom”. The participation in online tasks was rated as 3.64-“often” by the study group and 2.53-“sometimes” by the control group. The high use of online resources was supported by the interview data, all interviewees reported extensive ongoing use of online resources including, all reporting participating in ongoing, online learning both formal and informal.

## **8.7 DISCUSSION COMPARING THE INTERVIEW REPOSSES AND THE WEBLEI DATA**

The goal of the interviews was to validate findings from the WEBLEI, explain questions raised by analysis of the WEBLEI data, and investigate further development of web-based 3D virtual learning environments. This was approached using semi-structured interviews focused on questions about engagement in online learning activities while at the polytechnic and the online study experience since graduating from the Information Technology programme. The resources and communication methods used during study were also investigated focusing on chat, social presence, and the use of 3D virtual worlds, including the potential of 3D virtual worlds as learning environments.

The interviews did validate the findings from the survey, and additionally they highlighted a gap in the survey instrument used for this study, the WEBLEI. The WEBLEI focused solely on web-based communication during the course and does not include reference to other complementary mechanisms which might be used for communication between students or between students and tutors. The interviews identified extensive use of SMS on mobile phones, and telephone voice calls, as additional methods of technology mediated communication with other students and

less frequently with tutors. These technologies were used primarily to coordinate and manage both the time and activities of students, in person and online.

This research began in 2002 when mobile phone use was expanding rapidly. At the end of 2003 more than 2,825,000, which is approximately 66% of New Zealanders had a mobile phone connection (Vodafone, 2004; Statistics New Zealand, 2004). At this time, the cost of mobile phone calls in New Zealand was still relatively expensive. However, the two major carriers were starting to offer bulk deals on SMS messaging. In Europe, the field of mLearning, using mobile technology to facilitate learning was starting and research projects around mobile learning were being initiated (Naismith & Corlett, 2006). In 2004, Stone conducted studies into students using SMS to manage both time and activities in physical and virtual space in the United Kingdom. First year students were given the opportunity to opt in to a SMS-based text alert system. The messages included class changes, deadline reminders, hints about assignments, and processes for assignment submission. The results indicated that this activity was well received by the students and the authors considered that this type of service had definite potential (Stone, 2004). These results may have a bias as the author reported a major campus wide outage of the campus Learning Management System during the trial.

SMS (Short Message Service) text messaging technology has been identified as one which students already use, and had indicated interest in the use of this as a support tool at a time they need it most, to address issues identified where such support is needed. (Stone, 2004, p. 405)

The interview results indicate that the students involved in the study described in this thesis were using mobile phones to coordinate activity without prompting by teaching staff. This opens up a different avenue of research to investigate how these mobile devices are being used as complementary technology to the technology provided by the tertiary institute. It would be useful to know if students are commonly using mobile technologies to manage their activities and time in both physical and virtual spaces. It would also be useful to know if they are not using mobile technologies, how they are managing to meet in the same space at the same time, to work together, or to gain support.

There is also potential to expand the scope of the survey instrument the WEBLEI, if it is to be used for further studies. The inclusion of questions around the use of complementary technologies would give a more complete picture of the communication between students and between students and tutors.

The interviews supported one of the themes identified in the responses to the open-ended WEBLEI questions with regard to student access to technology and affordable internet access. However, the request for access to more feedback through chat was not repeated in the interviews. The interviews also provided support for the lack of use of forums, and the students' preferences to use email as the main form of web-based communication. The interviews also reinforced the students' perceptions identified by the WEBLEI that it requires self discipline to work in web-based environments. The interviews identified time wasting, addictive properties of web-based chat, and online games that include social presence mechanisms.

The interviews also raised a new theme for consideration about the mechanisms available for group coordination to enable it to meet, either online or in person, at a specific place and time. They also raised questions about the use of discussion boards and forums as communication tools for learning.

## **8.8 EXPLORATION OF ISSUES IDENTIFIED FROM THE WEBLEI**

The second focus of the interviews was to gain an understanding regarding the questions raised through analysis of logs and survey data around the apparent lack of use of the chat facilities and resources in the 3D virtual world sites identified earlier in Chapter Six. When asked about their participation in the 3D virtual world site all focused on the site they designed and created. For example, one student said, "Oh yes I made a math's game... a maze". The chat and resources embedded were not mentioned, and when the interviewer asked about the facilities available in the 3D virtual worlds, descriptions of the avatars were given. Two of those interviewed followed up with a discussion about the Personal Digital Assistant (PDA) application they created in the second project for the course and one moved on to a lengthy discussion about employment opportunities in the fields related to construction of 3D virtual worlds, including the local computer game industry.

This does raise questions about the suitability of this participative approach and the inclusion of the students in the design, building, and evaluation of the environments. The aim of using the participative design process was to explore a range of ideas on suitable designs that included the students' perspective, while also giving students personal office space in the environment. The aim was to provide a space similar to giving students web server space to publish their own home pages, when they are studying web site development; and giving students common rooms and study spaces on a physical campus. It was expected that this would give students a sense of ownership and would encourage students to use the virtual space. However, the effect was that the students focused on creating their own space as an encapsulated project. Once the project was finished they moved on to the next task in the course. This attitude is reflected in the log data, which only shows significant activity during the building projects, the evaluation and teaching sessions.

## **8.9 EXPLORE POTENTIAL OF 3D VIRTUAL ENVIRONMENTS FOR LEARNING**

The third objective of the interviews was to seek views on the further development of 3D virtual worlds. At the time of the interviews, the virtual world *Second Life* was getting significant positive media coverage and attention from researchers in eBusiness. The stories covered emerging business models, stories of people moving businesses into second life and the development of a second life economy (Cagnina & Poian, 2007; Craig, 2006; Kim, Lyons & Cunningham, 2008; Making a Living in Second Life, 2006). However, when asked about experience with 3D virtual worlds, only one person mentioned *Second Life*, the others mentioned *Adobe Atmosphere* and online games. When asked which 3D virtual worlds they had used the responses included *Atmosphere*; *Second Life* and online games; various games such as *Battlefield* were mentioned.

When asked about using the *Adobe Atmosphere* world at the polytechnic, even direct questions such as "Did you use it?", "Was it useful?", "What sort of activities?" did not elicit responses that were on topic. The universal responses to these questions related to building their own worlds, including descriptions of the worlds and the tasks involved to build them. Questions seeking to identify the uses

related to communication or learning activities involved received no answers on topic.

The last set of questions were focused on the potential of 3D virtual worlds for learning and were designed to prompt for answers around the potential and possible composition of these worlds. For example, how do you think online study could include 3D virtual worlds for learning? What sort of resources should be in a 3D virtual world for study? Do you think it would affect your use online resources if they were in a 3D virtual world? Who do you think you would communicate with?

The answers to these questions centred on games blended with learning, and the newer generation who are coming through schools now. Below are some examples of the comments:

*People look online more than they look in books quite honestly, if you can combine learning with games that's good* Student 1

*online more interactive* Student 2

*they don't read books* Student 4

*online repeatable* Student 5

*a whole different dynamic* Student 4

*good for younger kids get a game where they don't know they are learning* Student 1

The comments although positive did not provide a great deal of information on future directions for the use of 3D virtual world technology for learning environments. The insightful comment “It’s a whole different dynamic”, combined with the number of responses indicating students do not take notes in classes or read books, offer an interesting perspective on the future path for learning. If these general observations are proven to be true for the majority of students entering tertiary education, one way forward could be through multimedia and interactive learning objects embedded in engaging online learning environments.

## **8.10 DISCUSSION**

This chapter has shown that the interview results are generally consistent with the survey results and validated many of the findings from the WEBLEI. There is considerable evidence that the interviews support the data from the survey as there are a number of corresponding themes in the WEBLEI open-ended question data and the interview data.

Both sets of data identify email as a primary communications mechanism. The findings from the interviews identified email as the preferred online interaction method, this was supported by an analysis of the relevant WEBLEI items, which identified that the preference for email was significantly greater in the study group, than the control group.

Both sets of data highlight the limitations of technology, including the inadequacy of the internet access available in the homes of students and graduates. This was a major barrier to students engaging with the online environments. The interviews indicate that this was still an issue in 2007.

Both sets of data support the perception that self-discipline is necessary to overcome the distractions presented by chat and online social presence to enable effective study in the web-based environment

The interview data also identified the low level of use of discussion boards (forums) which supports the WEBLEI findings. The high use of online resources by the study group was identified in both the survey and interview data. This was rated significantly greater for the study group than the control group in the WEBLEI analyses.

The interview data highlighted new issues related to the communication necessary for the coordination of groups. These issues included both the mechanisms to coordinate both physical and virtual meetings in time and space and the inability to share work products between group members working together in web-based environments.

The interviews highlighted the use of non web-based technologies, such as SMS messages and mobile phone conversations, to provide additional

communication channels to supplement the students' interactions. Future investigations into student learning environments might include these communication channels in the instrument design.

The findings from the analysis of the WEBLEI open-ended question data, that students would like more access to chat as a method of communicating with other students and tutors was not supported by the interview data. It is possible that the reference to chat systems was referring to non web-based chat, perhaps using mobile phones, in which case the interview data may corroborate the open-ended question data.

Exploration during the interviews into the use of the 3D virtual environments, specifically the lack of use of the worlds during the latter parts of the course, found that the students had focused on the building tasks to the exclusion of using them as a learning space. It was very difficult to draw any comments on the use of the *Adobe Atmosphere* world that did not relate to the building process. Interviewees moved from discussions about building *Adobe Atmosphere* worlds, to the next building project in the course, or to discussions about employment in fields associated with building virtual worlds.

Interview questions about the future of 3D virtual worlds in education, did not draw direct support or opposition for their use as learning environments. The interviewees commented on the relationship of younger people with traditional and new media and a new dynamic, as it became uncommon to handwrite notes and read books. This interview group had an age range at the time of the interviews of 25 to 41, the mean age was 31. This was an older group than those currently participating in the same programme of tertiary study, in part because they were all now graduated.

The age range of students who participated in using the web-based 3D virtual worlds, over the eight years the research was conducted, was 20 to 58 years old with a mean age of 26.6 years. Table 8.3 shows the mean age for each year group of students. The intake of new students into the same degree paper at the polytechnic in 2010 has an age range of 20 to 42 and a mean of 24.6. This is a different demographic to those who participated in this research. The means of student ages

slowly moved closer to the digital native group over the research period. In addition the year that the WEBLEI data were gathered, 2005, was for one of the younger groups of students.

Table 8.2  
*Mean of Student Ages by Year*

Year	Mean of student age
2003	29.3
2004	28.3
2005	25.7
2007	27.3
2008	26.1
2009	25.3
2010	24.6

Note: There was no use of the web-based 3D virtual learning environments by students in 2003 and 2006.

## **8.12 SUMMARY**

This chapter reported that the interview results were generally consistent with the WEBLEI results and validated many of the findings from the analysis of the WEBLEI data, log data, and design data. The chapter has drawn together the interview data and the WEBLEI data identifying common themes and providing explanations for some of the observed phenomena. Chapter Nine synthesises and integrates the analysis of the different data presented in Chapters Six, Seven and Eight.

## **CHAPTER 9**

### **DISCUSSION**

Every teacher is always a pupil and every pupil a teacher.  
(Gramsci, 1971, p. 350)

#### **9.1 INTRODUCTION**

This research utilized a bricolage of research methods to design, build, and use, web-based 3D virtual learning environments. It quantified the usage and utilization of these environments, analysed the data collected, and finally sought explanations for the phenomena observed through triangulation of the data. Triangulation techniques were used to enhance the rigour of the study. These techniques were applied throughout the research project at data source, data collection, and data analysis levels.

Staff and students from an Information Technology degree programme at one New Zealand Polytechnic participated in this study. The design and use of 3D web-based virtual learning environments were integrated into one paper for five iterations of the research. Two iterations were conducted with small group projects. Data were collected from these research iterations plus control data were collected from the programme in which it was embedded. Analyses of these data included collation of statistically significant relationships between environmental factors and the design features of the 3D web-based virtual learning environments created.

#### **9.2 DATA ANALYSIS RESEARCH FOCUS QUESTIONS**

This thesis reports research that involved seven iterations of research data gathering. Data were collected from: the WEBLEI survey; artefacts from the 3D worlds designed and developed by the researcher; artefacts from the 3D worlds designed and developed by the students; the web-based environments created by the researcher and those created by the students; online activity logs, and logs of chat sessions. Follow-up interviews were conducted with a sample of students after the completion of their study.

These data were analysed to seek answers to specific research focus questions developed in Chapter Four section 4.4.5. These questions were identified to focus the data analyses, while seeking answers to the overall research questions identified in Chapter One. The detailed analyses were discussed in three chapters. Chapter Six presented the detailed analysis of the WEBLEI data triangulated with an analysis of log data. Chapter Seven presented the detailed analysis of the design data. Chapter Eight triangulated the WEBLEI and log data to the interview data. The findings from these analyses of the data are summarised in sections 9.2.1 to 9.2.12, through answers to the research focus questions identified in Chapter Four section 4.4.5.

### **9.2.1 What are the students' perception of the 3D learning environment?**

The WEBLEI data indicated that the students enjoyed using the web-based 3D virtual learning environment and that students participating in the trial perceived their learning environment more favourably than did those in the control group. They found the access to the web-based learning materials convenient and efficient. They had the opportunity to participate and interact regularly with each other and the teacher, and perceived a sense of satisfaction and achievement from completing their study. They strongly advocated that it be available to more online courses. The interview responses did not support or oppose the use of 3D virtual worlds as learning environments, they did indicate that in the future students would be at home in this type of environment.

### **9.2.2 Does the relationship between students' perception of their learning environment differ between students who use the 3D environment and students who do not?**

The Mann-Whitney *U* test examining the Z-score and the two-tailed P-value on the four scales of the WEBLEI data indicated that there was no significant difference for the Results scale. However, there was a significant difference in the Access, Interaction, and Response scales for the study group in the expected direction. This indicates that the study group perceived these scales more favourably than did the control group, resulting in a more favourable learning environment. Therefore, there was no ill effect from participation in the trial, and no indication that the participants in the trial were in any way disadvantaged. Nor did they perceive their learning environment to be any less effective than those who were not involved.

The analyses of the WEBLEI data indicated that the use of the web-based 3D virtual learning environment significantly enhanced the perceptions of the participants in the trial. However, it did not identify particular reasons why the study group perceived their learning environment as more engaging. The interview data, suggested that the students were very interested in the development of the 3D virtual environments, however they found the technology a novelty rather than a tool to use.

### **9.2.3 What is the relationship between the 3D learning environment and levels of student-to-student interaction?**

The discussion in 6.7 of the log data did not indicate that the use of the web-based 3D virtual learning environment led to more student-to-student interactions occurring. However, analysis of the WEBLEI data did show higher student perceptions on the Interaction scale for students participating in the study. The Mann-Whitney *U* test examining the Z-score and the two-tailed P-value on the four scales of the WEBLEI indicated that the difference of perceptions was significant on the Interaction scale. The interview data did indicate a high level of student-to-student interaction while studying independently. However, this was through telephone calls, mobile phone text messages and other chat software such as *Microsoft Messenger*.

### **9.2.4 What is the relationship between students' perception of their learning environment and the levels of interaction between student peers?**

Analysis of the WEBLEI data did indicate a relationship between the Interaction scale and the students overall perception of their environment. The Mann-Whitney *U* test showed that the study group had a significantly higher overall perception of their learning environment on the Interaction scale. The interview data did indicate a high level of interaction using alternative communication channels. This could have contributed to the students' perception of their learning environment and should be investigated further.

### **9.2.5 What is the relationship between the 3D learning environment and levels of student-tutor interaction?**

The discussion of the log data in 6.7 did not indicate that the use of the web-based 3D virtual learning environment led to more student-tutor interactions

occurring. Although the analyses of the WEBLEI did indicate that the students using the web-based 3D learning environment perceived more interaction with the tutors than did the control group, it does not appear they were using this method for communication.

The interview data did not indicate that students were using alternative communication channels such as mobile phones or SMS to communicate with tutors, although they did report using these channels to communicate with other students. However, the interview data did indicate that students were using email to contact tutors, this could be the reason students in the study group perceived higher levels of interaction with their tutors.

#### **9.2.6 What is the relationship between students' perception of their learning environment and the levels of interaction between students and tutors?**

The WEBLEI data did indicate a relationship between the Interaction scale and the students overall perception of their learning environment. The study group had a higher overall perception of their learning environment on the four scales of the WEBLEI. The Mann-Whitney test indicated that this was significant on the Interaction scale. The interview data did report using email to contact tutors, but did not indicate that the 3D software, telephones or chat software were used to interact with tutors.

#### **9.2.7 What are the interactions taking place in the web-based 3D learning environment?**

This was answered in Chapter 6 section 6.7 through the log data recorded by the software. The logs showed that the only usage was that observed during class sessions and that the students were not using the chat facilities or other methods of interacting in the web-based 3D virtual learning environment as an integral part of their regular self-directed study practice. The interview data also indicate that the students were not in the habit of using the environments they created as a method of studying outside class time. The data did indicate that the main activities associated with the 3D worlds were designing and building the 3D worlds.

### **9.2.8 Are there differences in participation/activity levels for any members of the study group?**

The logs showed that students were using the environments for structured class activities only. These activities were structured to ensure that all students participated. The interview data also supported the concept of compulsory requirements to ensure everyone participates. One student stated that “tasks should be mandatory” to ensure people participate.

### **9.2.9 Does a difference in participation/activity levels affect the student perception of their learning environment?**

The interview responses support the results of the analysis of the WEBLEI and log data. From the levels of participation recorded and reported that outside organised class activities, the environments were rarely used for chat, and there were rarely any synchronous participants in any one environment. Yet the analyses of the WEBLEI data showed that the students in the study group perceived their interaction levels and their learning environment more favourably than those in the control group strongly advocating for it to be expanded to more online courses. This was reinforced by the interview data, as it was very difficult to elicit responses to questions asking about non-class activities that took place using the 3D world.

### **9.2.10 What are the learning activities that need to take place in the 3D environment?**

The first designs were informed by the literature on learning discussed in Chapter Two, which provided a summary of theories of learning, social interaction, and relationships between teachers, learners and the environment to facilitate learning. These theories provide a guide to the learning activities that need to take place in a web-based 3D learning environment to enable different modes of learning.

These theories were used to benchmark the worlds created through this research, measuring how well the different modes of learning, defined by theory, were catered for. Each iteration of the research sought to expand the activities available to cater for modes of learning further along each continuum. The 3D virtual learning environments, created during this research, provided support for some of the modes of learning in the behaviourist and cognitivist range of the

learning theory continuum but had only limited support for constructivist and connectivist modes of learning. The worlds created also provided for a mostly teacher centric view of learning with some support for an andragogical perspective, however there was little support for learners to take control of their learning to create a heutagogical learning space.

The following learning activities were incorporated into the main class worlds during this research: access to course related information such as assignment tasks, and deadlines; review class notes and attend/replay lectures, discuss/clarify with other students and tutors, arrange meetings; relieve boredom, stress, and isolation when working outside class times by chatting to other students. Many other activities have been discussed that were not able to be implemented using the technologies available during this research. Additionally, the students identified several categories of learning activities that had not been identified by the researcher. These involved: social activities, supporting relaxation, such as games and listening to music; access to other web-based information resources; and group collaboration activities, such as access to diaries and sharing of work. Chapter Seven, contains detailed lists of activities and features that should be considered for inclusion in future web-based 3D learning environments.

#### **9.2.11 What are the elements of the designs for future web-based 3D learning environment?**

The design elements are based on user experience goals and usability goals. The students identified the desirable user experience goals as “fun” and “enjoyable”, followed by “motivating”. The researcher identified the desirable user experience goals as “engaging” and “motivating”. Both the students and the researcher identified “motivating” as a desirable user experience design element, however the students emphasised “fun” as the most important design element to include in 3D learning environments.

The top three usability goals identified by the students were “learnability”, “efficiency”, and “effective”. The researcher identified “learnability” and “effective” as the usability goals for the web-based 3D learning environment. The students’ identification of “efficiency” as their second most important usability goal is

interesting, as it corroborates the findings in Chapter Six section six. The open-ended question data from the WEBLEI identified that time saving was frequently cited as one of the reasons for, and advantages of, studying online. In addition, one of the issues the students encountered when studying in this mode was inadequate technology to use the web-based 3D learning environment. While there was no strong direction from the interview data about the elements required in the design of future worlds, the task of designing had captivated the students and the quality of the graphics and the avatars was discussed. Analyses of the data indicate that a fun, easy to learn environment that enables the students to accomplish their learning task in an efficient manner is a goal for the design of future environments.

#### **9.2.12 What are the features required for web-based 3D learning environments?**

These have been listed in order of popularity in Figure 7.11, and Table 7.3 gives a breakdown of these features, by those implemented in the web-based 3D virtual learning environment, those available when the web-based 3D virtual learning environment was integrated into the *Blackboard* learning management system, and those not implemented in this research. The interview data highlighted important features to be considered in future developments. These include areas of group communication particularly coordination mechanisms and sharing of work products. They also indicated that the communication systems need to be extended to mobile phone technology to increase synchronous communication.

### **9.3 RESEARCH QUESTIONS**

This research thesis sought to answer a number of research questions identified in Chapter One section 1.4. Data were analysed in relation to specific research focus questions and these have been discussed in sections 9.2.1 through 9.2.12. This section discusses the findings from these focus questions. The first of the research questions is answered in section 9.3.1, and was the focus of this thesis, which was to determine whether the 3D virtual education environments developed were compelling engaging, and provided an environment that enabled learners to experience success. The second group of questions is answered in sections 9.3.2 through 9.3.4, and sought to provide guidance and insight into features that are desirable in web-based 3D learning environments. The third group of questions,

answered in sections 9.3.5 through 9.3.8, sought to explore the effect of avatars and participant lists providing awareness of the other participants who are online.

### **9.3.1 Is the environment, engaging, compelling, motivating?**

The design documentation identified the user experience goals as “fun” and “enjoyable”, followed by “motivating” suggesting that these are the experiences that the students had, or expected to have, in the web-based 3D virtual learning environments. Analyses of the WEBLEI data indicated that the study group perceived their learning environment more favourably than did the control group and they strongly advocated for it to be expanded to more online courses. During the interviews, the interviewees were animated and enthusiastic when discussing the 3D virtual worlds; however, they were non-committal about the use of 3D worlds for learning, identifying the environments as most suitable for children. These data all indicate that the environment is engaging, compelling and motivating.

### **9.3.2 What are the interactions between students, teachers, tutors that contribute to the learning process?**

Interaction in learning environments was defined, in Chapter Two, as occurring between, learners and content, learners and learners, learners and teachers, teachers and teachers, plus teachers and content. Each of these interactions was described as essential for learners to create meaning and understanding. The dialogue between learners, and other learners, content, and teachers all contribute to the learning experience. The web-based 3D virtual learning environment was initially designed to enable interaction between learners and between learners and teachers using the 3D technology. Over the course of the research the communications channels used included: text chat, animated avatars, text and images embedded in the worlds, voice chat, pre-recorded sound, recorded video, live voice with slide show, and a shared whiteboard. These technologies were implemented in phases. The early iterations emphasised person-to-person interaction with little stored content included. Each subsequent iteration provided additional facilities for learner-content and person-to-person interaction, with the final version emphasising the content ahead of the dialogue between learners.

Analysis of the designs identified a number of interactions that were not able to be implemented with the technology available. It highlighted additional interactions to be included in future developments, focusing on sharing work with other students and teachers. The research also found that the learners used many different technology channels to communicate with each other when studying independently.

### **9.3.3 How do these interactions facilitate the process of passing on knowledge and learning?**

Interaction in learning environments was discussed in Chapter Two. The literature suggests that the dialogue between students, content, and teachers all contribute to learning. Different theories of learning establish different priorities for interaction in the learning process, with behaviourism having the least emphasis on interaction to constructivism which has a very high emphasis on interaction and the emerging theory of connectivism which places interaction into the centre of understanding.

The implications for the design of web-based 3D virtual learning environments were discussed in Chapter Seven, including the restrictions imposed by the available technology. The findings from the data analyses, discussed in Chapter Six, found the following: there was an indication of a strong relationship between the Interaction scale on the WEBLEI and the overall perception of the learning environment; students participated enthusiastically in well-structured compulsory activities; however, the students were not using the environment for interaction outside class time. The Mann-Whitney *U* test examining the Z-score and the two-tailed P-value on the four scales of the WEBLEI data indicated that there was a significant difference in the Access, Interaction, and Response scales for the study group, with the study group showing significantly higher means on these three scales. Although this identified the interaction scale as a factor in the students' greater perception of their learning environment, this analysis does not provide answers to the question above, as the hoped for interactions did not occur within the web-based 3D virtual learning environment it was not possible to analyse the type of interactions taking place.

However responses to interview questions discussed in section 8.5, provide an insight into the role that planned and impromptu interaction with peers did play to support successful learning, with comments such as “get help from friends”, “MSN at three in the morning”, “if it wasn’t for the people - I wouldn’t have got through”, describing working on assessment tasks. This supports Vygotsky’s, ZPD, enabling the completion of tasks in advance of an individual’s capability through the support of a more experienced peer, and the critical role that enabling these interactions had in the students learning to provide timely information and fresh insight..

#### **9.3.4 How are these interactions facilitated in the web-based 3D virtual education environment?**

The web-based 3D virtual learning environment was designed taking these interactions into consideration. However, the technology did not enable as many different channels as are currently available in a physical space. The research reports that the students participating in this study found additional technology channels, such as MSN and SMS useful to supplement the web-based channels provided. The students participating in this research did not find the 3D virtual environments used in this research to be very useful in facilitating independent study. The rich experience of a classroom or group study space was not able to be replicated sufficiently using the technology available in this research to provide a successful environment for independent study.

#### **9.3.5 How do people build up trust to talk to fellow students, to ask questions?**

The interviews indicated that the students did build up sufficient relationships through their interactions in the classroom, 3D virtual environment, and independent study to ask questions privately using other electronic systems including email and *Microsoft Messenger*. However, they did not report using public electronic systems such as forums unless it was mandatory, nor did they use the 3D virtual world chat system unless it was mandatory. The information given to the students regarding participation in the project did include a statement that all chat was being recorded for the purpose of this research (see Appendix F). It is possible that this affected the students’ willingness to use this channel to communicate during independent study.

### **9.3.6 Is lurking (observing without interacting directly with other participants) a common phenomenon?**

In this research, lurking was described as people who engaged in legitimate peripheral participation. As was described in Chapter Two, it was expected that the use of the web-based 3D virtual learning environment would identify the students who were in attendance, but not contributing to discussions, as their presence would be signified by their avatar being present in the 3D virtual environments, and the lack of input would be recorded in the chat logs. Analysis of the data available suggests that lurking was common, as people would log in then leave without chatting or engaging with anyone or anything in the environment. This may have been because there was no coordination mechanism built in to enable the synchronisation that would facilitate groups of people to be in the virtual environment concurrently. At any time, there was a relatively small group of students involved, the minimum was three, and the maximum was 20. Each of these students had access to a number of different independent worlds, including the worlds created by each class member, in addition to the class world. This would have made it relatively unlikely that more than one student would decide to go to any specific world at the same time. In addition, some of the features requested, but not implemented, included diaries, calendars and group coordination mechanisms, which indicate that the students wanted to be able to use coordination mechanisms to enable groups to meet. However, this study also identified that the students who completed the WEBLEI lurked on forums as well, and the students interviewed, reported that they only posted to forums when it was a compulsory part of the paper, suggesting that it was a common strategy employed by the group.

### **9.3.7 If lurking is common what makes a difference to the lurking phenomena?**

As lurking was apparently very common during this study, it is not possible from the data collected to identify any strategies to alter this behaviour other than the ones employed when students did participate in the online activities. These focused mainly on teacher directed activities requiring contributions from the students. One example is that during organised synchronous class sessions the structure was imposed by the tutor, with inclusive techniques, such as organised requests for a specific student to provide input, to ensure all participated. This structure was

imposed on the class sessions because the inbuilt chat system in this product had a single window with the input from each person sequentially added to the window. This was very difficult to follow, if the chat was not directed, when a group was present. Another example of tutor direction to require contributions, was provided by the interviewees, who indicated that forum contributions should be compulsory, as they only contributed when compelled to do so.

### **9.3.8 If lurking is common, does participation by lurking affect people's perspective of the environment?**

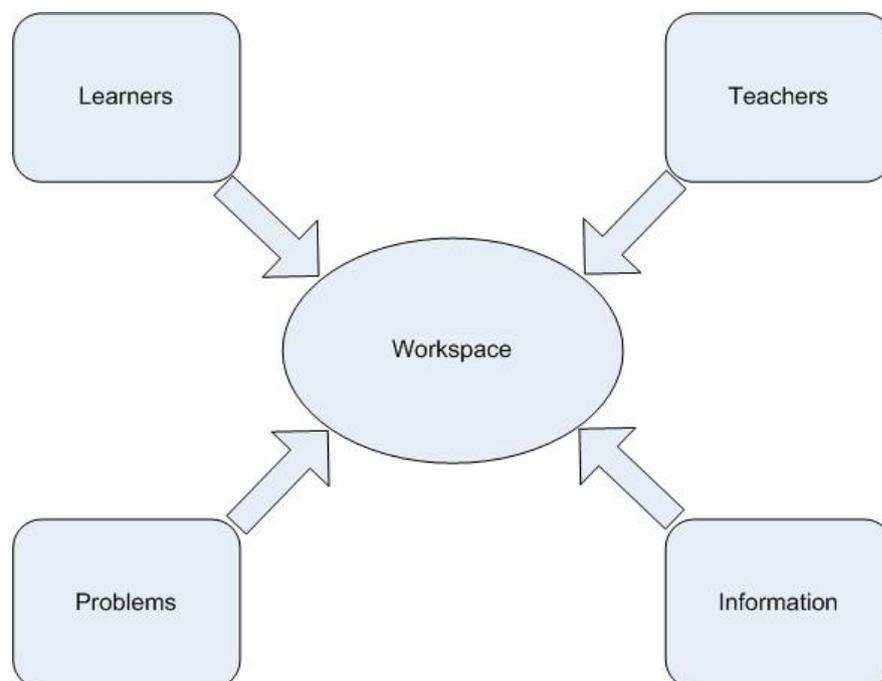
From the analysis of the data gathered with the WEBLEI, the interviews and the logs, it appears that the lurking phenomena was a common form of student participation in this course, with the exception of structured teaching sessions. The suggestions for additional features in the design indicate that this was caused in part by the lack of features to support group coordination, resulting in it being an unlikely coincidence for two or more members of the study group to appear synchronously in the environment by chance. This does not appear to have affected the students' perceptions of the environment in a negative way, the WEBLEI results showed the students participating in the study group perceived their learning environment more favourably than did those in the control group.

### **9.3.9 Summary**

During the research, analysis of the data indicated that the web-based 3D virtual learning environment was not getting the usage anticipated. This caused a change in focus, away from analysing the usage data to enable optimisation of the web-based 3D virtual learning environment, to analysing the data to gain an understanding as to why the usage was very low. Initially, the problem was identified as a need to embed the course information into the environment. The subsequent designs were refined to add more embedded information, until the technology became unstable and it was not technically possible to support more embedded information. These attempts to integrate embedded information, to be accessed on demand, were not very successful with the tools used in this research. The tools focused on synchronous activity and largely ignored methods of providing historical records and asynchronous information. On demand video, was integrated

in version three of the main class world to allow students to replay any of the lecture sessions from earlier in the paper but the bandwidth required to load a number of videos in one world was very high. The software always loaded the complete world including all the components even if they might not be required when the world was being explored. This created a world that was very difficult to use as it was extremely slow and unresponsive. The last design solved the inability to embed more information in the 3D virtual environment by embedding the 3D virtual learning environment in the course information web pages. This resulted in a little more use; however, it was still far short of the usage expected.

The models of learning that show interaction between learners, teachers, information and problems, infer a space where these can be worked with collaboratively. This space was missing in the learning environment created during this research. There was no synchronous workspace provided where a teacher could work through a task modelling the actual work or where the students could show the teacher, or another student the processes they were using to solve the problem.



*Figure 9.1.* Workspace is required to learn collaboratively.

Imagine teaching a student to hammer in a nail to join two pieces of wood, the problem is to join piece of wood A, to piece of wood B, using a nail and a hammer. The teacher is someone experienced at joining wood with a hammer and a nail, the learner is not experienced in using the hammer and nail or familiar with the technique for hammering nails. The information on how to do this could be provided as written instructions, diagrams, videos, or teacher demonstrations. The workspace is a joint space where hammers, nails, wood, learner, information, and teacher are all present at the same time. Without the workspace containing all these components, the learner only has the option to learn the “theory” of hammering in a nail. Without a teacher present, participating in the workspace, the information may not be applied correctly to the problem, resulting in frustration for the learner, as there is no feedback loop in the process. When a learner is working on a problem with a teacher present there is a process of feedback that enables the teacher to monitor the use of the information and guide the problem solving. Without a student present, the teacher can only give a presentation, without feedback from a learner they cannot ensure the information is being received and understood. When a teacher is imparting information to a learner, there is a process of feedback from the student letting the teacher know how the information is being received and enabling the teacher to adjust the process of imparting the information. How is this shared workspace to be created in a virtual environment, to enable these immediate feedback and adjustment processes to occur?

#### **9.4 RECOMMENDATIONS FOR FUTURE RESEARCH**

This research has identified that the web-based 3D virtual learning environment was well received by the students and worthy of further research. A number of areas were identified that were unable to be investigated with the technologies available at the time. The research has also highlighted a range of phenomenon that should be investigated further.

The research identified that students were engaged with multiple technologies to communicate about their learning. This study focussed solely on internet-based communication, with a heavy focus on the channels provided through the 3D world; however, the students identified multiple other channels they were using, including, in person meetings, other txt chat systems, telephones, and mobile phones. Further

research is necessary into the roles that these communication channels have in student-to-student interactions while learning. The survey instrument did not include these channels and it may be of interest to introduce items into the scales to allow for these (and future) technology mediated channels.

As the technology used is no longer available, to continue this research new technologies will need to be selected. Features have been identified by this research to inform this selection process, Chapter Seven identifies and ranks desirable features to be included in future 3D learning environments, many of which were not able to be included in the environments used for this research. Future research projects will enable the investigation of the impact of these features.

With the technology available, this research was able to create 3D virtual learning environments that provided support for modes of learning primarily in the behaviourist and cognitivist range of the learning theory continuum, as technology develops, future research should investigate the provision of support for constructivist and connectivist modes of learning.

The 3D worlds created also provided for a mostly teacher centric view of learning with some support for an andragogical perspective. Future research should expand this to provision support for learners to take control of their learning creating andragogical and heutagogical learning spaces.

This research was a small prototype case study, a proof of concept. It identified that the priorities for students participating in this research were that it was fun, easy to learn and an efficient environment for learning. Further study is required to validate this finding. To further investigate the utility of this type of technology for both learners and teachers, this study needs to be extended to larger groups, different types of classes, different types of learning activities and fully distance classes. As the technology matures, the integration with database technology to manage the learning environments' participants and resources will also need to be investigated.

Two important missing features were identified; the first was related to facilitating the synchronous use of the 3D world for self-directed study and small group study activities. The feature missing was an integrated mechanism to

coordinate meetings in time and virtual spaces. Without this feature, meeting another student or teacher in the 3D worlds outside the set class times had a very low chance of occurring. Mechanisms to facilitate synchronous activity require further investigation.

The second critical issue identified was the lack of a means to share work products between members of the class. When the work product was the creation of the worlds themselves, the task of designing and building the worlds captivated the students and they were the most fully engaged with the environments. However, the lack of facilities to share other types of work, to enable group problem solving and mentoring was a major issue. This reduced the usefulness of the worlds for the other workshop and applied project activities used in this class. Emerging technologies for 3D worlds such as *Open Wonderland* (2007), allow application sharing within the environments, giving the potential to enable a much larger range of work product sharing in future worlds. The role that this sharing has in enabling learning merits further investigation.

This research suggests an emerging perception, particularly among those interviewed that there is an epistemological change occurring, that the relationship of students to traditional media is changing, one student identified that “It’s a whole different dynamic”. In general, it was apparent that there was a perception that, students are becoming more engaged with technology-mediated information and less engaged with traditional paper-based information sources, and that technology mediated information is an enabling technology for both connectivist theories of learning and heutagogical approaches to learning. This phenomenon requires further investigation as to; how real it actually is, and the impact it could have on education, learning, and society.

## **9.5 LIMITATIONS**

Chapter One outlines the scope of this research. By conducting the inquiry as a small prototype case study this research is not directly repeatable. The WEBLEI data were collected during only one of the research cycles, from eleven students who were part of the study group and 49 students who were not part of the study group. The design data were collected from seven iterations of the study from 71 students.

Four of these groups had access to a main class world and three did not. The number of students in each iteration was too small to enable meaningful comparisons between the individual groups or between the groups who had access to the main class world and those that did not. Different results and possibly different conclusions that could be derived from repeating the data collection remain unknown. As each case is unique, wider generalisations should be treated with caution. This study is relevant to the technology used, and this is no longer available. Newer technologies will enable a different experience, possibly leading to different results and different conclusions.

The survey instrument, the WEBLEI, was administered on paper by a staff member who was not involved in the research. It was completed by students during class time. This was only administered during one iteration of the virtual learning environment trial. It collected data from eleven members of the study group and 49 members of a control group. These numbers are small, and although they give an indication of differences between the two groups, wider generalisation of these findings should be treated with caution.

The server logs were kept throughout the four iterations of the research conducted with whole classes using the 3D virtual environments, the web server log data kept count of access to download pages from the web server. If students used copies of the worlds stored on local hard drives instead of downloading the virtual worlds each time they connected to them, as a means of minimising internet traffic, their connections to the worlds would not have been registered.

The chat logs recorded the messages published in the in-world chat system. It was apparent from the interviews that students were commonly using other internet-based chat systems to communicate, giving them ready access to an alternative chat channel. The students had been informed that chat in the web-based 3D virtual world was being logged, this may have resulted in a reluctance to use this communication channel. These factors may have compromised the data collected in the logs resulting in under reporting of the use of these web-based communication channels.

The class-based trials were conducted in classes run by the researcher. This could have introduced researcher bias as it was participant observation. The data were collected by means other than direct observation to mitigate the probability of participant researcher observer bias.

The interviews were conducted by the researcher after the students had completed their qualifications. This resulted in a delay of up to two and a half years from the participation in the trial to the date of the interview. The reason for the delay was to ensure that there was no bias introduced due to the researcher being able to affect their progress towards their qualification. The delay may have introduced a bias as the use of the technology was not fresh in the interviewees' minds. The delay did however; introduce some interesting workplace-based perspectives on the technology, as the graduates interviewed were all in employment in information technology related positions at the time of the interviews.

The design documentation analysed in Chapter Seven was collected from a student assessment task. The students were aware that it was contributing to the research as well as to their grades. The grading system was not related to the analysis of the data, and no assessment data were analysed for the purpose of this research before the course marks were allocated and returned to the students.

## **9.6 IMPLICATIONS**

This research has identified that the web-based 3D virtual learning environments were well received by students who enjoyed using the environments. Results show significant potential for the future of these learning environments. The technology has no negative effect on students' perceptions of their learning environment.

This research went through four iterations with a full class participating in the worlds. These iterations included designing creating and using web-based 3D virtual learning environments for a class in a blended delivery environment. The first was based on a soapbox metaphor and consisted of an open space surrounding a podium and cube used to display slides, the next was based on a gallery metaphor and also was a large space with a number of additional features. These consisted of, a replay screen for the last lecture, a music kiosk and a link to the class *Blackboard* based

resources. The third was an ambitious attempt to integrate the majority of the *Blackboard* based resources into the 3D virtual world following a plaza metaphor. This overstretched the technology available at the time, resulting in very poor performance for the students and tutors using the worlds. The final design was a lecture space based on the gallery metaphor, and was embedded in the *Blackboard* resource page.

The evolution of the designs went from a tutor-controlled space where students and tutors could meet, with the only information provided by synchronous interaction. This was followed by two versions that integrated the course information into the 3D space and then the last design which embedded the 3D meeting space into web pages that contained the course information. This evolution reflects the technology available at the time, but also raises questions related to the nature of the medium and how to use it effectively as a learning environment.

While the study has shown the use of these environments to be engaging for students, this research has raised significant issues about the capability of the technology, and suitable designs to support synchronous and asynchronous participation in a collaborative workspace.

The medium of 3D virtual worlds promises a collaboration space, its effectiveness is demonstrated in MMORPGs, enabling large forces to gather and work to a common objective. In these MMORPGs the work tasks are simple, players collaborate to hunt and gather. Players can move, pick up objects, and exchange objects. They can speak using voice and gesture; they can use one object on another for example players can hit each other. These 3D virtual worlds have developed to enable large groups to work together hunting and gathering but do not facilitate groups crafting and creating solutions to problems. The challenge is now to develop ways to facilitate complex tasks to be accomplished within these worlds.

As technology develops, the issues encountered regarding network access and speed, the technology limitations preventing computers to displaying the worlds, and the inability of avatars to move freely in these environments, will be resolved. Once these are resolved, it will enable a common workspace to share work in progress, to enable feedback loops to occur and benefit the whole group from this feedback. This

will enable learning to take place as is currently possible in a classroom or computer lab.

Learning is a very complex activity and the development of environments to facilitate it is a significant challenge. This research identified areas of interest relating to the designs of the learning environments, and activities undertaken in them. The findings suggest directions for future research and development of web-based 3D virtual world technologies to further the realisation of their potential to provision immersive learning environments.

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## APPENDICES

### APPENDIX A

#### WEBLEI

#### WEB-BASED LEARNING ENVIRONMENT INSTRUMENT

##### Directions for respondents

This survey contains two sections.

Section one, personal details, contains 5 questions and is used for statistical purposes. Participants **cannot be identified** in anyway.

Section two, web-based learning environment, contains statements related to your learning in a web-based learning environment. You will be asked how often each practice takes place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think how well each statement describes what the web-based learning environment is like for you.

Draw a circle around

- |          |                             |                  |
|----------|-----------------------------|------------------|
| <b>1</b> | if the practice takes place | <b>Never</b>     |
| <b>2</b> | if the practice takes place | <b>Seldom</b>    |
| <b>3</b> | if the practice takes place | <b>Sometimes</b> |
| <b>4</b> | if the practice takes place | <b>Often</b>     |
| <b>5</b> | if the practice takes place | <b>Always</b>    |

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

<b>PERSONAL DETAILS</b>
-------------------------

The personal information requested in this section of the survey is for **statistical purposes only**.

At no stage will this information be used for any other purpose. Your answers to the questions will remain confidential and you **cannot be identified** in any way.

For each statement, please **circle** the answer which best represents your answer.

1. Gender	Male Female
2. Age Group	Under 25 25 - 40 over 40

**COMPUTER USE**

For each statement, please **circle** the number that best represents your answer.

	Daily	3 times a week	Once a week	Once a month	Less than once a month
3. I use my home computer	5	4	3	2	1
4. I use the internet	5	4	3	2	1
5. I log on to Blackboard	5	4	3	2	1
6. I log on to Blackboard from a computer that is not in a classroom	5	4	3	2	1

## WEB-BASED LEARNING ENVIRONMENT

For each statement, please **circle** the number that best represents your answer.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

### ACCESS

	Always	Often	Sometimes	Seldom	Never
7. I can access the online learning activities at times convenient to me.	5	4	3	2	1
8. The online material is available at locations suitable for me.	5	4	3	2	1
9. I can use time saved for study and other commitments.	5	4	3	2	1
10. I am allowed to work at my own pace to achieve learning objectives.	5	4	3	2	1
11. I decide how much I want to learn in a given period.	5	4	3	2	1
12. I decide when I want to learn.	5	4	3	2	1
13. The flexibility allows me to spend more time learning	5	4	3	2	1
14. The flexibility allows me to meet my learning goals.	5	4	3	2	1
15. The flexibility allows me to explore my own areas of interest.	5	4	3	2	1

## INTERACTION

	Always	Often	Sometimes	Seldom	Never
16. I communicate with other students in my classes by email.	5	4	3	2	1
17. I communicate with other students in my classes through a discussion board.	5	4	3	2	1
18. I communicate with other students in my classes electronically using chat.	5	4	3	2	1
19. I communicate with other students in my classes electronically using a electronic whiteboard.	5	4	3	2	1
20. I communicate with other students in my classes electronically using a group workspace.	5	4	3	2	1
21. I have to be self disciplined in order to learn in this online environment.	5	4	3	2	1
22. I use electronic methods to ask my tutor for help when I do not understand.	5	4	3	2	1
23. I use electronic methods to ask other students for help when I do not understand.	5	4	3	2	1

24. Other students respond promptly to my queries electronically.	5	4	3	2	1
25. The tutor responds promptly to my queries electronically.	5	4	3	2	1
26. I participate in online tasks.	5	4	3	2	1
27. I am supported by positive attitudes from my peers	5	4	3	2	1

## RESPONSE

	Always	Often	Sometimes	Seldom	Never
28. This method of learning enables me to interact with other students and the tutor asynchronously*.	5	4	3	2	1
29. This method of learning enables me to interact with other students and the tutor synchronously**.	5	4	3	2	1

\* Synchronously: happening at the same time

\*\* Asynchronously happening at different times

30. I felt a sense of satisfaction and achievement about the electronic learning environment.	5	4	3	2	1
31. I enjoy learning in the electronic environment.	5	4	3	2	1

32. I could learn more in the electronic environment.	5	4	3	2	1
33. It is easy to organize a group for a project electronically.	5	4	3	2	1
34. It is easy to work collaboratively with other students involved in a group project electronically.	5	4	3	2	1
35. The electronic learning environment held my interest throughout my course of study.	5	4	3	2	1
36. I felt a sense of boredom towards the end of my course of study.	5	4	3	2	1

## RESULTS

	Always	Often	Sometimes	Seldom	Never
37. The scope or learning objectives are clearly stated in each part of the electronic learning material.	5	4	3	2	1
38. The organization of each part of the electronic learning material is easy to follow.	5	4	3	2	1
39. The electronic structure keeps me focused on what is to be learned.	5	4	3	2	1
40. Expectations of assignments are clearly stated in the electronic material.	5	4	3	2	1

41. Activities are planned carefully.	5	4	3	2	1
42. The subject content is appropriate for delivery on the Web.	5	4	3	2	1
43. The web-based presentation of the subject content is clear.	5	4	3	2	1
44. The quizzes in the web-based materials enhance my learning process.	5	4	3	2	1
45. The videos in the web-based material enhance my learning.	5	4	3	2	1

<b>OPEN-ENDED COMMENTS</b>
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Please write your responses in the spaces provided below. Your comments could provide an explanation of previous responses and/or additional information you may wish to provide.

1. Why do you study in online web-based mode?

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2. What are the advantages of studying in an online web-based mode?

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3. What are the disadvantages of studying in an online web-based mode?

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4. Are there any suggestions to improve delivery of the module in an online web-based mode?

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5. I would be interested in a follow-up interview.

No

Yes      I can be contacted on: Phone: ( )

Email:

---

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## **APPENDIX B**

### **CONSENT FORMS FOR PARTICIPANTS**

#### **Script read to Participants in the Survey and Interviews**

I am currently involved in a research project at the Science and Mathematics Education Centre (SMEC), Curtin University of Technology, as part of my Doctoral degree. I wish to inform you that I am conducting a study titled “Building a Virtual Classroom: An Education Environment for the Internet Generation”.

The purpose of the study is to investigate how multi-user online environments can be used as learning environments for educational purposes. This study is unique in that it focuses on the communication activities of participants in a multi-user online learning environment helping establish how this behaviour affects learning outcomes. I wish to survey participants about their experience using online learning environments for education. My reading in my own studies has indicated that online environments are engaging environments that enable a wide range of communication opportunities to support the learning process.

In this study I will be asking students to complete questionnaires. As with any research, ethical considerations are paramount in my study. I will ensure that no action taken in my study will impinge on the rights of students or my work colleagues. I have given due consideration to privacy and confidentiality issues in my study. The anonymity of individual students and teachers will be preserved throughout as identification numbers will be used for all the data analysis. All data collected will be treated as confidential and published results will not reveal individual student or teacher names.

If you wish to discuss my study please contact me at:

Sue Chard  
Faculty of Business and Information Technology

Thank you for your kind cooperation.

## Consent form for participants

**PhD Topic :** Building a Virtual Classroom: An Education Environment for the Internet Generation

**Researcher:** Sue Chard

**University:** Curtin University, Perth, Australia

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This study into the use of web based learning environments, is investigating the effects of the use of 3D multi-user online environment for education. Questionnaires are being used to evaluate the perceptions of all participants, both staff and students. In addition interviews are being conducted with a representative group of participants to gather a broad range of views of the web based learning environment.

All data collected will be archived in a secure area with any names of participants removed. A copy of my findings will be made available to all participants.

(Would you please read and sign the following consent form for this interview – included when interviewing)

### Participation Consent

I agree to participate in this study into the use of web based learning environments on the understanding that:

- I am free to withdraw at any time
- If there is a question I would prefer not to answer that will be respected.
- Confidentiality will be maintained, my identity will not be shared with other parties and all material will be kept in secure storage.
- The data collected will be used as part of the published thesis, (but I may check interview notes immediately after the interview and indicate any sections of the interview that I would prefer not to be used.- included for interviews)
- A summary of statistical data and interview results will be made available to all participants should I be interested in the results.

Signed (participant) \_\_\_\_\_

Date \_\_\_\_\_

Signed (researcher) \_\_\_\_\_

Date \_\_\_\_\_

## APPENDIX C

### INTERVIEW QUESTIONS

#### Interview Questions

Interviewee /time Audio filename filename	Interview date  Transcript
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Read consent etc,

1. Could you describe your online experience generally: Describe the types of online activities you use.
2. Have you/are you using online study support or studying online?
3. What was your experience of online study at the polytech
4. What sort of resources [prompts: communications channels were used / email /forum/ chat /shared whiteboard/voice] for study
5. Did your online study have any ability to chat and include social presence

Did you use it, was it useful, what sort of activities

Who did /would you use it to communicate with

Would online presence affect your use of the online resources

6. 3D worlds, have you used any.... in relation to online courses

Did you use it, was it useful, what sort of activities

Who did you communicate with using it

7. How do you think online study could include 3D worlds for learning?

Do you think it would affect your use online resources if they were in a 3d world?

Who do you think you would communicate with?

8. Online experience generally, describe the types of online uses

[Prompts: Email / Browsing / ecommerce / games

## APPENDIX D

### STATISTICAL TABLES

#### DESCRIPTIVE STATISTICS FOR COMPUTER USE SCALE

Descriptives Computer Use Scale					
	Control			Statistic	Std. Error
Computer Use	0	Mean		4.0455	.15007
		95% Confidence Interval for Mean	Lower Bound	3.7111	
			Upper Bound	4.3798	
		5% Trimmed Mean		4.0505	
		Median		4.0000	
		Variance		.248	
		Std. Deviation		.49772	
		Minimum		3.25	
		Maximum		4.75	
		Range		1.50	
		Interquartile Range		1.00	
		Skewness		-.212	.661
		Kurtosis		-1.295	1.279
	1	Mean		3.6382	.14840
		95% Confidence Interval for Mean	Lower Bound	3.3375	
			Upper Bound	3.9388	
		5% Trimmed Mean		3.7186	
		Median		3.7500	
		Variance		.837	
		Std. Deviation		.91478	
		Minimum		.00	
		Maximum		5.00	
		Range		5.00	
Interquartile Range		1.00			
Skewness		-1.836	.383		
Kurtosis		5.657	.750		

## DESCRIPTIVE STATISTICS ACCESS SCALE

Descriptives Access Scale					
	Control			Statistic	Std. Error
Access	0	Mean		3.6162	.12920
		95% Confidence Interval for Mean	Lower Bound	3.3283	
			Upper Bound	3.9040	
		5% Trimmed Mean		3.6352	
		Median		3.6667	
		Variance		.184	
		Std. Deviation		.42850	
		Minimum		2.67	
		Maximum		4.22	
		Range		1.56	
		Interquartile Range		.67	
		Skewness		-.778	.661
		Kurtosis		1.501	1.279
		1	Mean		3.2749
	95% Confidence Interval for Mean		Lower Bound	3.0824	
			Upper Bound	3.4673	
	5% Trimmed Mean		3.2979		
	Median		3.2222		
	Variance		.343		
	Std. Deviation		.58552		
	Minimum		1.11		
	Maximum		4.44		
	Range		3.33		
	Interquartile Range		.56		
	Skewness		-1.012	.383	
Kurtosis		4.101	.750		

**DESCRIPTIVE STATISTICS INTERACTION SCALE**

Descriptives					
	Control			Statistic	Std. Error
Interaction	0	Mean		2.8106	.23918
		95% Confidence Interval for Mean	Lower Bound	2.2777	
			Upper Bound	3.3435	
		5% Trimmed Mean		2.8035	
		Median		2.9167	
		Variance		.629	
		Std. Deviation		.79328	
		Minimum		1.58	
		Maximum		4.17	
		Range		2.58	
		Interquartile Range		1.08	
		Skewness		-.206	.661
	Kurtosis		-.221	1.279	
	1	Mean		2.2939	.13389
		95% Confidence Interval for Mean	Lower Bound	2.0226	
			Upper Bound	2.5651	
		5% Trimmed Mean		2.2500	
		Median		2.3333	
		Variance		.681	
		Std. Deviation		.82535	
		Minimum		.92	
		Maximum		4.50	
		Range		3.58	
		Interquartile Range		1.17	
Skewness		.601	.383		
Kurtosis		.503	.750		

**DESCRIPTIVE STATISTICS RESPONSE SCALE**

Descriptives					
	Control			Statistic	Std. Error
Response	0	Mean		3.6364	.16555
		95% Confidence Interval for Mean	Lower Bound	3.2675	
			Upper Bound	4.0052	
		5% Trimmed Mean		3.6453	
		Median		3.6667	
		Variance		.301	
		Std. Deviation		.54905	
		Minimum		2.67	
		Maximum		4.44	
		Range		1.78	
		Interquartile Range		.78	
		Skewness		-.287	.661
		Kurtosis		-.294	1.279
		1	Mean		2.8450
	95% Confidence Interval for Mean		Lower Bound	2.5016	
			Upper Bound	3.1884	
	5% Trimmed Mean		2.9139		
	Median		3.1667		
	Variance		1.091		
	Std. Deviation		1.04473		
	Minimum		.00		
	Maximum		4.56		
	Range		4.56		
	Interquartile Range		.78		
Skewness		-1.403	.383		
Kurtosis		1.710	.750		

## DESCRIPTIVE STATISTICS RESULTS SCALE

Descriptives					
	Control			Statistic	Std. Error
<b>Results</b>	<b>0</b>	<b>Mean</b>		3.7778	.16412
		<b>95% Confidence Interval for Mean</b>	<b>Lower Bound</b>	3.4121	
			<b>Upper Bound</b>	4.1435	
		<b>5% Trimmed Mean</b>		3.7840	
		<b>Median</b>		3.8889	
		<b>Variance</b>		.296	
		<b>Std. Deviation</b>		.54433	
		<b>Minimum</b>		2.78	
		<b>Maximum</b>		4.67	
		<b>Range</b>		1.89	
		<b>Interquartile Range</b>		.56	
		<b>Skewness</b>		-.424	.661
		<b>Kurtosis</b>		.226	1.279
		<b>1</b>	<b>Mean</b>		3.0789
	<b>95% Confidence Interval for Mean</b>		<b>Lower Bound</b>	2.6234	
			<b>Upper Bound</b>	3.5345	
	<b>5% Trimmed Mean</b>		3.1556		
	<b>Median</b>		3.5000		
	<b>Variance</b>		1.921		
	<b>Std. Deviation</b>		1.38607		
	<b>Minimum</b>		.00		
	<b>Maximum</b>		4.78		
	<b>Range</b>		4.78		
	<b>Interquartile Range</b>		1.22		
<b>Skewness</b>			-1.105	.383	
<b>Kurtosis</b>			.474	.750	

## **APPENDIX E**

### **EXAMPLE ASSIGNMENTS TO DESIGN AND CREATE A WEB-BASED 3D LEARNING ENVIRONMENT**

#### **Example Assessment from 2005**

**Purpose:**

This assignment requires you to apply the principles of Interaction design, to a design project for a 3D environment.

**Topic:**

The design and creation of a working prototype for a 3D web-based environment using Adobe Atmosphere for the use of this class.

**Part 1**

1. Identify the needs the environment is to satisfy
2. Identify specific usability goals and user experience goals for the 3D environment.
3. Identify two target user groups and create user profiles (personas) for them.
4. Identify the important user activities and create scenarios for these activities.
5. Design a low fidelity prototype to meet the needs described in 1-5

**Part 2**

Create a working prototype based on the low fidelity prototype, to be linked to the main class web-based environment

#### **Example Assessment from 2007**

**Purpose**

This assignment requires you to apply the principles of Interaction design, to a design project for a 3D environment.

The problem space is defined as developing a solution that will improve the user experience for students studying at home. This includes both students studying a course offered solely online and students who are studying an on campus course working at home on assignments. The solution proposed is to increase opportunities for:

- interaction between students and teachers
- provide access to the information they need for their course
- provide a more compelling experience to students.

**Topic**

1. Compare the features available for two 3D web based multi user environments – examples are Adobe Atmosphere, Second Life, Active worlds. .
2. Describe specific usability goals and specific user experience goals
3. Identify a target user group and create two user profiles (personas).
4. Document the important user activities that will take place in the environment
5. Make a recommendation for one 3D web based multi user environment to be used to develop an education support system to replace/augment Blackboard to support students who are studying off campus. Explain your choice based on 1 - 4 above.
6. Design and create a low fidelity prototype for a 3D web based environment, using the selected online 3D environment, to meet the needs identified in 2 - 4 above.

## **APPENDIX F**

### **EXAMPLE DOCUMENTATION**

The following are examples of the design documentation created by students in response to the assessment task. These documents were included in the analysis.

#### **EXAMPLE USER PROFILES**

##### **User Profile 1 – Zoe Williams**

Zoe is 22 years old and is a third year student studying the Bachelor of Information Technology (BIT). Zoe has grown up with computers as her father has been a computer engineer. She began programming at a young age and considers herself a very experienced computer user.

Zoe pushes all computer applications to the limit and likes to explore them to see what they can do. She likes “hacking” into computer systems as a challenge. Although she does not try to deliberately sabotage a system, she has little regard if she breaks a system and blames it on the bad system.

If a computer system does not work as she expects then Zoe easily gets frustrated very easily. She often tries to fix the problem herself if she can.

Zoe considers her completing and passing the BIT as a foregone conclusion and so only learns what she needs to learn. She likes to learn by using a “hands-on” approach.

Zoe does not see the need for 3D EE as she can already do what she needs already. She will use it but only if it will allow her to do what she needs.

##### **User Profile 2 – Joe Bloggs**

Joe is a 32 year-old student who has just started studying the Certificate in Practical Photography. For over ten years Joe has been a bus driver driving tourist buses all over New Zealand but last year was made redundant from his job. Joe wishes to turn his hobby in photography into his new career.

Joe has little experience with computers apart from basic word processing and internet usage. He has also used his computer to manage his digital photos. But Joe is quick to learn and is willing to learn as much he can. He wants to learn how to use his computer for photo editing which he currently does not know how to do. He also hopes to publish his photos to website.

Joe thinks the 3D EE would be a good idea and would be willing to use it. He finds the idea an exciting way to interact with other students.

#### **EXAMPLE USER EXPERIENCE GOALS**

The 3D EE should be:

- enjoyable to use
- encourage sociability and interaction
- entertaining to use

- enable users to collaborate and work together on tasks
- not be frustrating to use
- provide a total multi-sensory experience e.g. sound and visual.

## **EXAMPLE USABILITY GOALS**

### **Effectiveness**

- The 3D Education Environment(3D EE) should allow users to get information they need such as announcements, grades, etc.
- The 3D EE should allow users to interact with each other e.g. using messaging and real-time chat.
- The 3D EE should allow users to learn e.g. by doing tutorials, watching movies, attending virtual lectures.

### **Efficiency**

- The users should be able to carry out their tasks in minimal steps.
- The users should be able to save landmarks within the 3D EE to easily get back to places where they have been.

### **Safety**

- The 3D EE should be “fool” proof and help prevent users from doing unwanted things e.g. such as falling off the edge of a cliff.
- If a user gets stuck in an unwanted place the 3D EE should allow them to go back to a familiar place.

### **Utility**

- The 3D EE should provide functions that are needed for learn and interaction e.g. Chat, messaging, tutorials

### **Learnability**

- The 3D EE should be easy for novice and experience computer users to use.
- The 3D EE should allow users to explore the environment.
- It should take minimal time to learn to carry out essential tasks.

### **Memorability**

- Users should not be required to relearn how to carry out tasks, especially those which are used infrequently

## **EXAMPLE SCENARIOS**

### **List of Scenarios for use of 3D world created by one student (each had a one paragraph write-up)**

1. Student at home working on assignment. Cannot find assignment sheet and needs info from it
2. Student at home working on assignment. Is unsure of requirements
3. Student at home working on assignment. Cannot understand assignment sheet
4. Student at home working on assignment. Is unsure of how to start
5. Student at home working on assignment. Is unsure they are doing the right thing
6. Student at home working on assignment. Is stuck on a compile error
7. Student at home working on assignment. Is stuck on a bug
8. Student at home working on assignment. Cannot get software to work
9. Student at home working on assignment. Is bored and feels lonely
10. Student at home working on assignment. Wants to know if others are panicking the same
11. Student at home working on assignment. Is checking for tomorrows work

## EXAMPLE USE CASE

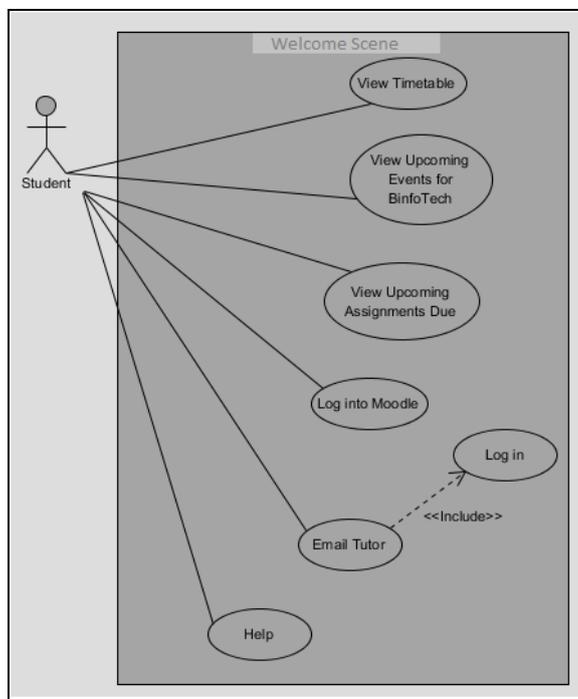
Welcome Screen Details

Name: Welcome Screen

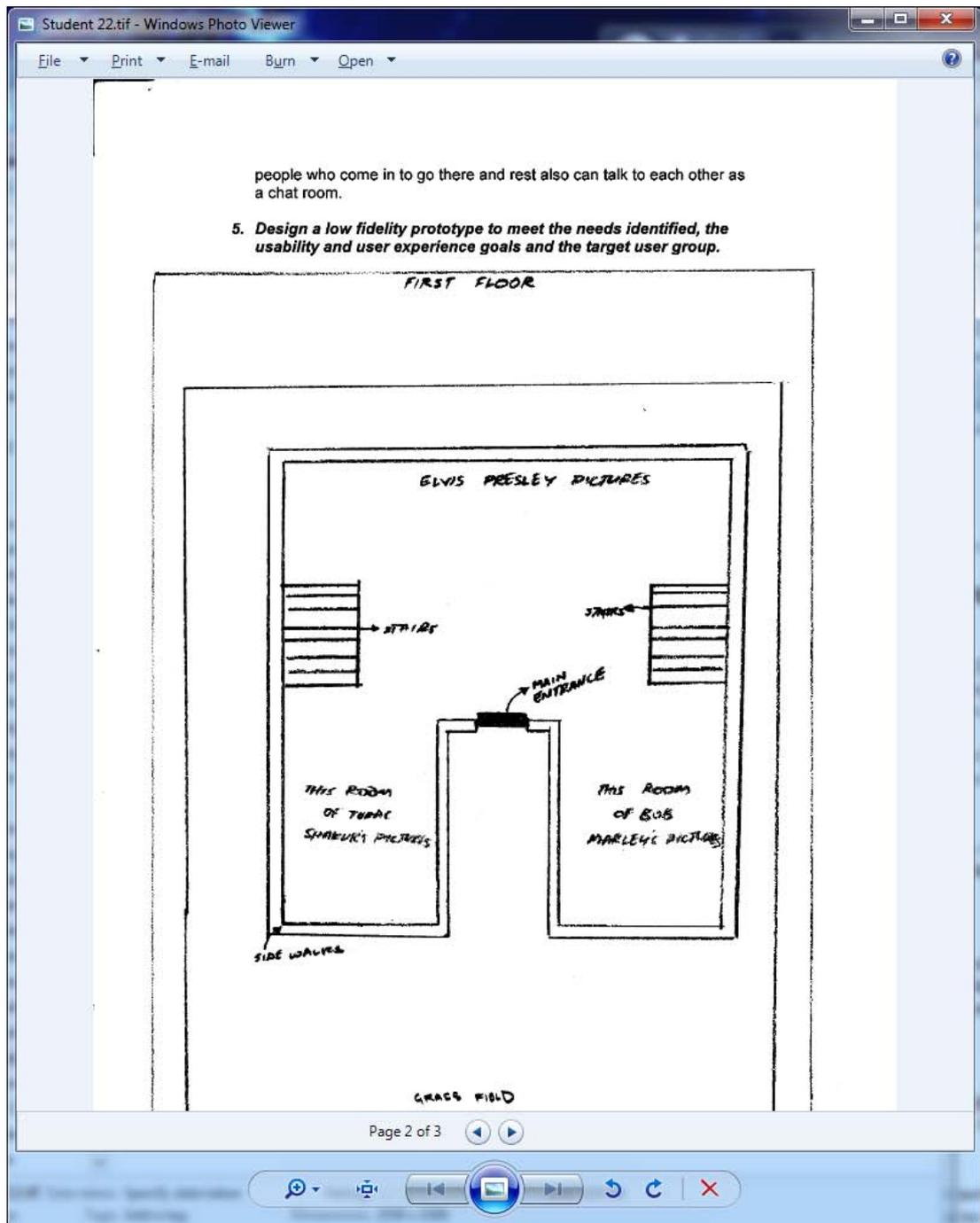
Info Description Diagrams

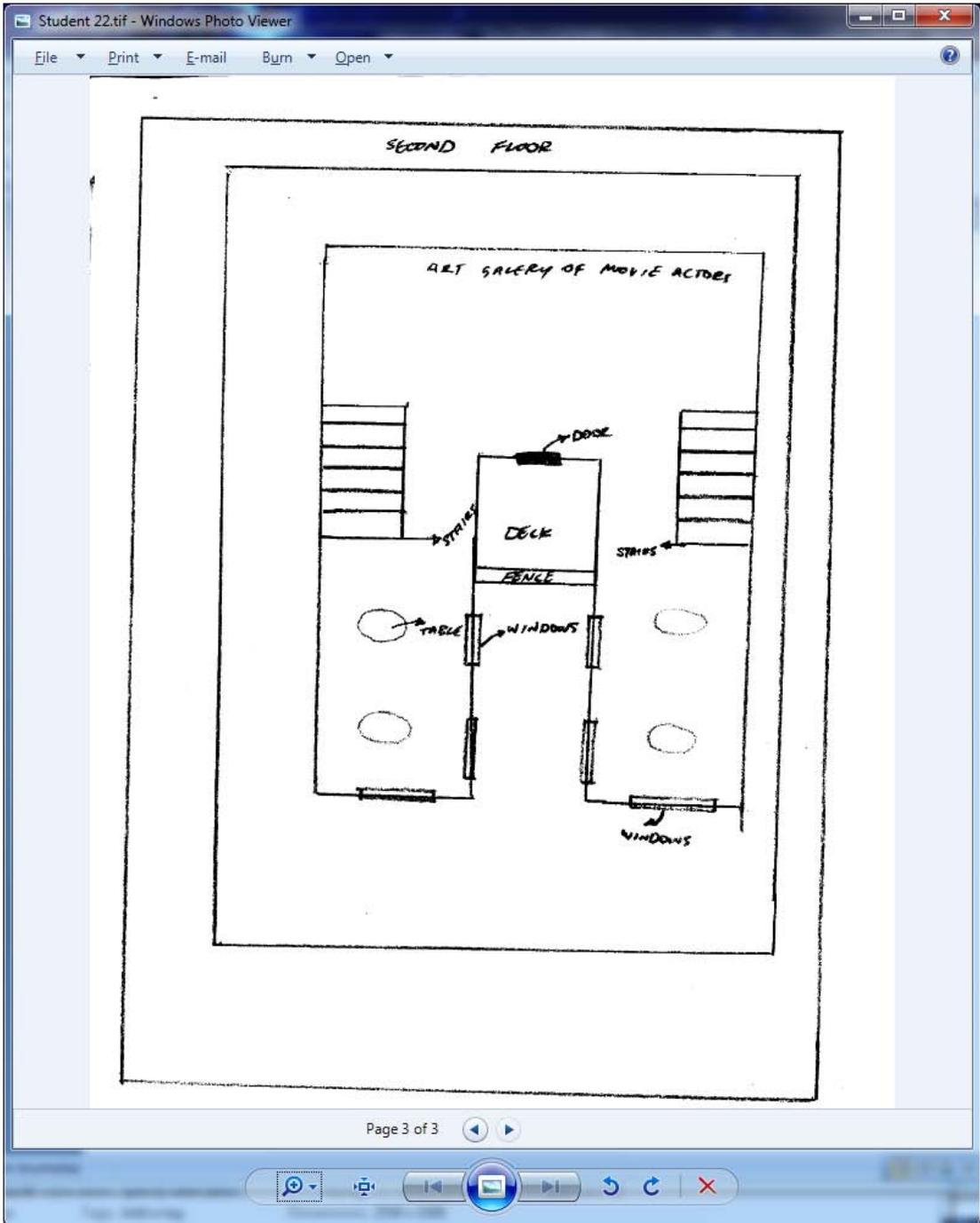
Agency FB 8

<b>Use Case ID</b>										
<b>Super Use Case</b>										
<b>Primary Actor</b>	Student									
<b>Secondary Actor(s)</b>										
<b>Brief Description</b>	This is when the student first uses the application									
<b>Preconditions</b>	program must be started.									
<b>Flow of Events</b>	<table border="1"> <thead> <tr> <th></th> <th>Actor Input</th> <th>System Response</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Student presses the Start button</td> <td></td> </tr> <tr> <td>2</td> <td></td> <td>System goes to the Getting Started</td> </tr> </tbody> </table>		Actor Input	System Response	1	Student presses the Start button		2		System goes to the Getting Started
		Actor Input	System Response							
1	Student presses the Start button									
2		System goes to the Getting Started								
<b>Post-conditions</b>										
<b>Alternative flows and exceptions</b>										
<b>Non-behavior requirements</b>										
<b>Assumptions</b>										
<b>Issue</b>										
<b>Source</b>										



## EXAMPLE LOW FIDELITY PROTOTYPE





## **APPENDIX G**

### **CONSENT FOR PARTICIPANTS**

#### **Script read to Participants studying IT308 Human Computer Interaction**

I am currently involved in a research project at the Science and Mathematics Education Centre (SMEC), Curtin University of Technology, as part of my Doctoral degree. I wish to inform you that I am conducting a study titled “Building a Virtual Classroom: An Education Environment for the Internet Generation”.

The purpose of the study is to investigate how multi-user online environments can be used as learning environments for educational purposes. This study is unique in that it focuses on the communication activities of participants in a multi-user online learning environment helping establish how this behaviour affects learning outcomes. My reading in my own studies has indicated that online environments are engaging environments that enable a wide range of communication opportunities to support the learning process.

In this study I will be recording some class sessions and class work for analysis after the paper is finished. No class recordings or work will be analysed until after the grades for the paper have been allocated. As with any research, ethical considerations are paramount in my study. I will ensure that no action taken in my study will impinge on the rights of students or my work colleagues. I have given due consideration to privacy and confidentiality issues in my study. The anonymity of individual students and teachers will be preserved throughout as identification numbers will be used for all the data analysis. All data collected will be treated as confidential and published results will not reveal individual student or teacher names.

If you wish to discuss my study please contact me at:

Sue Chard  
Faculty of Business and Information Technology

Thank you for your kind cooperation.

## **APPENDIX H**

### **LESSONS LEARNED FROM A TECHNOLOGY PERSPECTIVE**

This is a summary of some of the technology challenges encountered while working on this research and the methods used mitigate them. The most fundamental advice is to keep the system as simple as possible and always have an alternative plan. Things will go wrong. In this research these ranged from small things to major problems. Examples include the audio streaming not working on a specific day, the internet connections not being available at a scheduled class session. Some of the major issues were a burglary resulting in the loss of machines and backup disks, and the organisations' network manager deciding that the ports used by the software were letting viruses onto the network.

As mentioned earlier, the software was withdrawn from sale midway through the research. To counter this type of event copies of all the software had been obtained and backed up, however it did alter the project from an evolutionary prototype that could one day become the virtual campus, to a prototype that was going to be discarded once the thesis was completed. This did alter the focus of the research, and the initial plan to link to a content management database to enable dynamic content delivery was not attempted. Ensuring that copies of all the software used were backed up at multiple sites and were able to be used was critical to the completion of the research. Where possible, use open source software as this can't be withdrawn from sale, and in a worst case scenario the development can be continued within the research project. The software included in the backups were the server operating system, the server software for the 3D world and the voice communications systems. The software backed up from the client side, was the operating system, the voice clients, the world builder, the standalone player, the browser plug-ins, all the components used in the worlds and the actual words created. Also, include data, writing and documentation in the backups.

A second strategy was to reduce the external control of the technology environment as much as possible, from the servers and network connections right through to the desktop environments in use. The fewer parties involved the simpler and easier it is to operate the system. When using beta software and new types of

service, corporate network managers are uncomfortable with the perceived risk to the IT infrastructure. Times when third party controlled network ports blocked access for some computer users caused some of the more intractable problems. The eventual environment for this research was based on servers outside the organisations network. As much of the hosting as possible was provided by a commercial web hosting company to ensure 24x7 operation. Specialised servers were on machines connected to the internet through an account and network infrastructure under my control. This did cause some administrative overhead, however it would not have been possible to get any of this system working without these servers.

This project required the students to also have access to the technology. This was not always possible for all students as the cost was too high for them. From an ethical perspective alternative arrangements had to be in place to ensure those students were not disadvantaged. The preferred solution would have been to provide students with the necessary technology however, there was no budget available to enable this. In a small way, this was achieved in some parts of the trial as headsets were provided to students who did not have their own when we were using the audio capability of the worlds. For future work, I plan to be able to offer students leased laptops to ensure that they have access to suitable technology.

The methodology chosen was an iterative evolutionary prototyping methodology. The basic strategy was to develop the system in small increments, testing and evaluating the success and usability after each stage. The results of the evaluation were then used as input to the next stage. This proved a useful strategy. The second part of the development methodology was to involve the students as active participants in designing, building, and evaluating the software. In the early stages this did create issues as the beta software was not very robust, causing some student angst at the time. However, the insight gained from the multiple perspectives was invaluable as the research progressed. For future work I would follow this approach again, although the very early trials may be with very senior students who are more aware of the challenges working with early stage software involves. However, the focus on building did appear to cause an effect in the research. Future research should include more participants who were simply users of the environment.